US009220500B2

(12) **United States Patent**
Swayze et al.

(10) **Patent No.: US 9,220,500 B2**
(45) **Date of Patent: Dec. 29, 2015**

(54) **TISSUE THICKNESS COMPENSATOR COMPRISING STRUCTURE TO PRODUCE A RESILIENT LOAD**

(75) Inventors: **Jeffrey S. Swayze**, Hamilton, OH (US); **Frederick E. Shelton, IV**, Hillsboro, OH (US); **Tamara Widenhouse**, Clarksville, OH (US); **Christopher W. Widenhouse**, Clarksville, OH (US); **Taylor W. Aronhalt**, Loveland, OH (US); **Charles J. Scheib**, Loveland, OH (US)

(73) Assignee: **Ethicon Endo-Surgery, Inc.**, Cincinnati, OH (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 659 days.

(21) Appl. No.: **13/433,148**

(22) Filed: **Mar. 28, 2012**

(65) **Prior Publication Data**

US 2012/0241501 A1 Sep. 27, 2012

Related U.S. Application Data

(63) Continuation-in-part of application No. 13/097,891, filed on Apr. 29, 2011, now Pat. No. 8,864,009, which is a continuation-in-part of application No. 12/894,377, filed on Sep. 30, 2010, now Pat. No. 8,393,514.

(51) **Int. Cl.**

A61B 17/072 (2006.01)
A61B 17/064 (2006.01)

(Continued)

(52) **U.S. Cl.**

CPC ***A61B 17/0643*** (2013.01); ***A61B 17/00491*** (2013.01); ***A61B 17/072*** (2013.01);

(Continued)

(58) **Field of Classification Search**

CPC A61B 17/11; A61B 17/07207; A61B 17/0644
USPC 227/175.1, 176.1, 178.1, 179.1, 180.1
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

66,052	A	6/1867	Smith
662,587	A	11/1900	Blake

(Continued)

FOREIGN PATENT DOCUMENTS

AU	2008207624	A1	3/2009
AU	2010214687	A1	9/2010

(Continued)

OTHER PUBLICATIONS

ASTM procedure D2240-00, "Standard Test Method for Rubber Property-Durometer Hardness," (Published Aug. 2000).

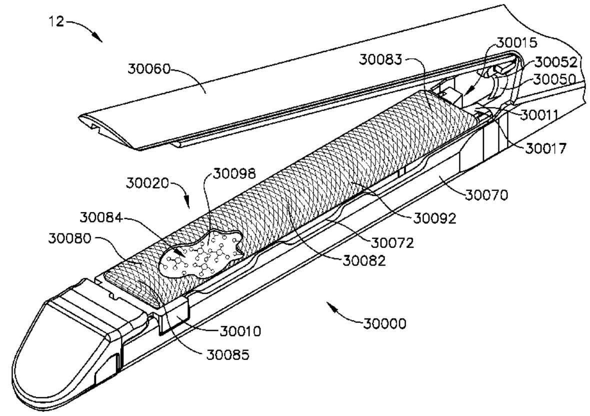
(Continued)

Primary Examiner — Nathaniel Chukwurah

(57) **ABSTRACT**

A fastener cartridge assembly for an end effector of a surgical instrument can comprise a cartridge body, a deformable tube, and a fastener moveable between an initial position and a fired position. The deformable tube can be longitudinally positioned along a length of the cartridge body. When the fastener is moved to the fired position, the fastener can compress a portion of the deformable tube. The deformable tube can comprise a resilient material such that deformation of the deformable tube generates a restoring force. The deformable tube can comprise a lattice of strands woven together to form a tube wall. Further, the deformable tube can be bioabsorbable and can hold a therapeutic agent. The fastener cartridge assembly can comprise multiple, substantially parallel deformable tubes positioned side-by-side and/or within each other.

20 Claims, 143 Drawing Sheets



(51) **Int. Cl.**

A61B 17/00	(2006.01)
A61B 17/115	(2006.01)
A61B 17/29	(2006.01)
A61B 17/32	(2006.01)

(52) **U.S. Cl.**

CPC ***A61B17/07207*** (2013.01); ***A61B 17/07292*** (2013.01); ***A61B 17/1155*** (2013.01); *A61B 17/0644* (2013.01); *A61B 17/2909* (2013.01); *A61B 2017/00004* (2013.01); *A61B 2017/0053* (2013.01); *A61B 2017/00314* (2013.01); *A61B 2017/00327* (2013.01); *A61B 2017/00526* (2013.01); *A61B 2017/00818* (2013.01); *A61B 2017/07228* (2013.01); *A61B 2017/07235* (2013.01); *A61B 2017/07242* (2013.01); *A61B 2017/07264* (2013.01); *A61B 2017/07271* (2013.01); *A61B 2017/07278* (2013.01); *A61B 2017/2908* (2013.01); *A61B 2017/2919* (2013.01); *A61B 2017/2923* (2013.01); *A61B 2017/2927* (2013.01); *A61B 2017/2933* (2013.01); *A61B 2017/2936* (2013.01); *A61B 2017/320052* (2013.01)

(56) **References Cited**

U.S. PATENT DOCUMENTS

670,748	A		3/1901	Weddeler
951,393	A		3/1910	Hahn
1,306,107	A		6/1919	Elliott
1,314,601	A		9/1919	McCaskey
1,677,337	A		7/1928	Grove
2,037,727	A		4/1936	La Chapelle
2,132,295	A		10/1938	Hawkins
2,161,632	A		6/1939	Nattenheimer
2,211,117	A		8/1940	Hess
2,214,870	A		9/1940	West
2,441,096	A		5/1948	Happe
2,526,902	A		10/1950	Rublee
2,674,149	A		4/1954	Benson
2,804,848	A		9/1957	O'Farrell et al.
2,808,482	A		10/1957	Zanichkowsky et al.
2,853,074	A		9/1958	Olson
2,959,974	A		11/1960	Emrick
3,032,769	A		5/1962	Palmer
3,075,062	A		1/1963	Iaccarino
3,078,465	A		2/1963	Bobrov
3,079,606	A		3/1963	Bobrov et al.
3,166,072	A		1/1965	Sullivan, Jr.
3,196,869	A	*	7/1965	Scholl 602/30
3,266,494	A		8/1966	Brownrigg et al.
3,269,630	A		8/1966	Fleischer
3,275,211	A		9/1966	Hirsch et al.
3,317,103	A		5/1967	Cullen et al.
3,317,105	A		5/1967	Astafjev et al.
3,357,296	A		12/1967	Lefever
3,490,675	A		1/1970	Green et al.
3,494,533	A		2/1970	Green et al.
3,499,591	A		3/1970	Green
3,551,987	A		1/1971	Wilkinson
3,572,159	A		3/1971	Tschanz
3,598,943	A		8/1971	Barrett
3,643,851	A		2/1972	Green et al.
3,662,939	A		5/1972	Bryan
3,717,294	A		2/1973	Green
3,734,207	A		5/1973	Fishbein
3,740,994	A		6/1973	DeCarlo, Jr.
3,744,495	A		7/1973	Johnson
3,746,002	A		7/1973	Haller
3,751,902	A		8/1973	Kingsbury et al.
3,819,100	A		6/1974	Noiles et al.
3,821,919	A		7/1974	Knohl
3,841,474	A		10/1974	Maier
3,851,196	A		11/1974	Hinds
3,885,491	A		5/1975	Curtis
3,892,228	A		7/1975	Mitsui
3,894,174	A		7/1975	Cartun
3,940,844	A		3/1976	Colby et al.
3,955,581	A		5/1976	Spasiano et al.
RE28,932	E		8/1976	Noiles et al.
3,981,051	A		9/1976	Brumlik
4,054,108	A		10/1977	Gill
4,060,089	A		11/1977	Noiles
4,106,446	A		8/1978	Yamada et al.
4,111,206	A		9/1978	Vishnevsky et al.
4,129,059	A		12/1978	Van Eck
4,169,990	A		10/1979	Lerdman
4,198,734	A		4/1980	Brumlik
4,198,982	A		4/1980	Fortner et al.
4,207,898	A		6/1980	Becht
4,213,562	A		7/1980	Garrett et al.
4,226,242	A		10/1980	Jarvik
4,244,372	A		1/1981	Kapitanov et al.
4,250,436	A		2/1981	Weissman
4,261,244	A		4/1981	Becht et al.
4,272,002	A		6/1981	Moshofsky
4,272,662	A		6/1981	Simpson
4,274,304	A		6/1981	Curtiss
4,275,813	A		6/1981	Noiles
4,289,133	A		9/1981	Rothfuss
4,305,539	A		12/1981	Korolkov et al.
4,312,685	A		1/1982	Riedl
4,317,451	A		3/1982	Cerwin et al.
4,321,002	A		3/1982	Froehlich
4,328,839	A		5/1982	Lyons et al.
4,331,277	A		5/1982	Green
4,340,331	A		7/1982	Savino
4,347,450	A		8/1982	Colligan
4,349,028	A		9/1982	Green
4,353,371	A		10/1982	Cosman
4,379,457	A		4/1983	Gravener et al.
4,380,312	A		4/1983	Landrus
4,382,326	A		5/1983	Rabuse
4,383,634	A		5/1983	Green
4,393,728	A		7/1983	Larson et al.
4,396,139	A		8/1983	Hall et al.
4,397,311	A		8/1983	Kanshin et al.
4,402,445	A		9/1983	Green
4,408,692	A		10/1983	Siegel et al.
4,409,057	A		10/1983	Molenda et al.
4,415,112	A		11/1983	Green
4,416,276	A		11/1983	Newton et al.
4,428,376	A		1/1984	Mericle
4,429,695	A		2/1984	Green
4,434,796	A		3/1984	Karapetian et al.
4,438,659	A		3/1984	Desplats
4,442,964	A		4/1984	Becht
4,451,743	A		5/1984	Suzuki et al.
4,454,887	A		6/1984	Krüger
4,467,805	A		8/1984	Fukuda
4,473,077	A		9/1984	Noiles et al.
4,475,679	A		10/1984	Fleury, Jr.
4,485,816	A		12/1984	Krumme
4,486,928	A		12/1984	Tucker et al.
4,488,523	A		12/1984	Shichman
4,489,875	A		12/1984	Crawford et al.
4,500,024	A		2/1985	DiGiovanni et al.
4,505,272	A		3/1985	Utyamyshev et al.
4,505,273	A		3/1985	Braun et al.
4,505,414	A		3/1985	Filipi
4,506,671	A		3/1985	Green
4,520,817	A		6/1985	Green
4,522,327	A		6/1985	Korthoff et al.
4,526,174	A		7/1985	Froehlich
4,527,724	A		7/1985	Chow et al.
4,530,453	A		7/1985	Green
4,531,522	A		7/1985	Bedi et al.
4,532,927	A		8/1985	Miksza, Jr.
4,548,202	A		10/1985	Duncan
4,565,109	A		1/1986	Tsay
4,565,189	A		1/1986	Mabuchi
4,566,620	A		1/1986	Green et al.
4,571,213	A		2/1986	Ishimoto

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,573,468	A	3/1986	Conta et al.
4,573,469	A	3/1986	Golden et al.
4,573,622	A	3/1986	Green et al.
4,576,167	A	3/1986	Noiles et al.
4,580,712	A	4/1986	Green
4,585,153	A	4/1986	Failla et al.
4,589,416	A	5/1986	Green
4,591,085	A	5/1986	Di Giovanni
4,600,037	A	7/1986	Hatten
4,604,786	A	8/1986	Howie, Jr.
4,605,001	A	8/1986	Rothfuss et al.
4,605,004	A	8/1986	Di Giovanni et al.
4,606,343	A	8/1986	Conta et al.
4,607,638	A	8/1986	Crainich
4,608,981	A	9/1986	Rothfuss et al.
4,610,250	A	9/1986	Green
4,610,383	A	9/1986	Rothfuss et al.
4,619,262	A	10/1986	Taylor
4,619,391	A	10/1986	Sharkany et al.
4,628,459	A	12/1986	Shinohara et al.
4,629,107	A	12/1986	Fedotov et al.
4,632,290	A	12/1986	Green et al.
4,633,874	A	1/1987	Chow et al.
4,634,419	A	1/1987	Kreizman et al.
4,641,076	A	2/1987	Linden
4,646,722	A	3/1987	Silverstein et al.
4,655,222	A	4/1987	Florez et al.
4,662,555	A	5/1987	Thornton
4,663,874	A	5/1987	Sano et al.
4,664,305	A	5/1987	Blake, III et al.
4,665,916	A	5/1987	Green
4,667,674	A	5/1987	Korthoff et al.
4,669,647	A	6/1987	Storace
4,671,445	A	6/1987	Barker et al.
4,676,245	A	6/1987	Fukuda
4,684,051	A	8/1987	Akopov et al.
4,693,248	A	9/1987	Failla
4,700,703	A	10/1987	Resnick et al.
4,708,141	A	11/1987	Inoue et al.
4,709,120	A	11/1987	Pearson
4,715,520	A	12/1987	Roehr, Jr. et al.
4,719,917	A	1/1988	Barrows et al.
4,727,308	A	2/1988	Huljak et al.
4,728,020	A	3/1988	Green et al.
4,728,876	A	3/1988	Mongeon et al.
4,729,260	A	3/1988	Dudden
4,730,726	A	3/1988	Holzwarth
4,741,336	A	5/1988	Failla et al.
4,743,214	A	5/1988	Tai-Cheng
4,747,820	A	5/1988	Hornlein et al.
4,750,902	A	6/1988	Wuchinich et al.
4,752,024	A	6/1988	Green et al.
4,754,909	A	7/1988	Barker et al.
4,767,044	A	8/1988	Green
4,773,420	A	9/1988	Green
4,777,780	A	10/1988	Holzwarth
4,787,387	A	11/1988	Burbank, III et al.
4,790,225	A	12/1988	Moody et al.
4,805,617	A	2/1989	Bedi et al.
4,805,823	A	2/1989	Rothfuss
4,809,695	A	3/1989	Gwathmey et al.
4,817,847	A	4/1989	Redtenbacher et al.
4,819,853	A	4/1989	Green
4,821,939	A	4/1989	Green
4,827,911	A	5/1989	Broadwin et al.
4,834,720	A	5/1989	Blinkhorn
4,844,068	A	7/1989	Arata et al.
4,848,637	A	7/1989	Pruitt
4,865,030	A	9/1989	Polyak
4,869,414	A	9/1989	Green et al.
4,869,415	A	9/1989	Fox
4,873,977	A	10/1989	Avant et al.
4,880,015	A	11/1989	Nierman
4,890,613	A	1/1990	Golden et al.
4,892,244	A	1/1990	Fox et al.
4,893,622	A	1/1990	Green et al.
4,896,678	A	1/1990	Ogawa
4,903,697	A	2/1990	Resnick et al.
4,915,100	A	4/1990	Green
4,930,503	A	6/1990	Pruitt
4,930,674	A	6/1990	Barak
4,931,047	A	6/1990	Broadwin et al.
4,932,960	A	6/1990	Green et al.
4,941,623	A	7/1990	Pruitt
4,944,443	A	7/1990	Oddsen et al.
4,955,959	A	9/1990	Tompkins et al.
4,965,709	A	10/1990	Ngo
4,973,274	A	11/1990	Hirukawa
4,978,049	A	12/1990	Green
4,978,333	A	12/1990	Broadwin et al.
4,986,808	A	1/1991	Broadwin et al.
4,988,334	A	1/1991	Hornlein et al.
5,002,543	A	3/1991	Bradshaw et al.
5,002,553	A	3/1991	Shiber
5,009,661	A	4/1991	Michelson
5,014,899	A	5/1991	Presty et al.
5,015,227	A	5/1991	Broadwin et al.
5,024,671	A	6/1991	Tu et al.
5,027,834	A	7/1991	Pruitt
5,031,814	A	7/1991	Tompkins et al.
5,038,109	A	8/1991	Goble et al.
5,040,715	A	8/1991	Green et al.
5,042,707	A	8/1991	Taheri
5,061,269	A	10/1991	Muller
5,062,563	A	11/1991	Green et al.
5,065,929	A	11/1991	Schulze et al.
5,071,052	A	12/1991	Rodak et al.
5,071,430	A	12/1991	de Salis et al.
5,074,454	A	12/1991	Peters
5,080,556	A	1/1992	Carreno
5,083,695	A	1/1992	Foslien et al.
5,084,057	A	1/1992	Green et al.
5,088,979	A	2/1992	Filipi et al.
5,088,997	A	2/1992	Delahuerga et al.
5,094,247	A	3/1992	Hernandez et al.
5,100,420	A	3/1992	Green et al.
5,104,025	A	4/1992	Main et al.
5,104,397	A	4/1992	Vasconcelos et al.
5,106,008	A	4/1992	Tompkins et al.
5,111,987	A	5/1992	Moeinzadeh et al.
5,116,349	A	5/1992	Aranyi
5,122,156	A	6/1992	Granger et al.
5,129,570	A	7/1992	Schulze et al.
5,137,198	A	8/1992	Nobis et al.
5,139,513	A	8/1992	Segato
5,141,144	A	8/1992	Foslien et al.
5,142,932	A	9/1992	Moya et al.
5,155,941	A	10/1992	Takahashi et al.
5,156,315	A	10/1992	Green et al.
5,156,609	A	10/1992	Nakao et al.
5,156,614	A	10/1992	Green et al.
5,158,567	A	10/1992	Green
D330,699	S	11/1992	Gill
5,163,598	A	11/1992	Peters et al.
5,171,247	A	12/1992	Hughett et al.
5,171,249	A	12/1992	Stefanchik et al.
5,171,253	A	12/1992	Klieman et al.
5,188,111	A	2/1993	Yates et al.
5,190,517	A	3/1993	Zieve et al.
5,192,288	A	3/1993	Thompson et al.
5,195,968	A	3/1993	Lundquist et al.
5,197,648	A	3/1993	Gingold
5,197,649	A	3/1993	Bessler et al.
5,200,280	A	4/1993	Karasa
5,205,459	A	4/1993	Brinkerhoff et al.
5,207,697	A	5/1993	Carusillo et al.
5,209,747	A	5/1993	Knoepfler
5,211,649	A	5/1993	Kohler et al.
5,211,655	A	5/1993	Hasson
5,217,457	A	6/1993	Delahuerga et al.
5,217,478	A	6/1993	Rexroth
5,219,111	A	6/1993	Bilotti et al.
5,221,036	A	6/1993	Takase
5,221,281	A	6/1993	Klicek

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,222,963 A 6/1993 Brinkerhoff et al.
5,222,975 A 6/1993 Crainich
5,222,976 A 6/1993 Yoon
5,223,675 A 6/1993 Taft
5,234,447 A 8/1993 Kaster et al.
5,236,440 A 8/1993 Hlavacek
5,239,981 A 8/1993 Anapliotis
5,240,163 A 8/1993 Stein et al.
5,242,457 A 9/1993 Akopov et al.
5,244,462 A 9/1993 Delahuerga et al.
5,246,156 A 9/1993 Rothfuss et al.
5,246,443 A 9/1993 Mai
5,253,793 A 10/1993 Green et al.
5,258,009 A 11/1993 Conners
5,258,012 A 11/1993 Luscombe et al.
5,259,366 A 11/1993 Reydel et al.
5,260,637 A 11/1993 Pizzi
5,263,629 A 11/1993 Trumbull et al.
5,263,973 A 11/1993 Cook
5,268,622 A 12/1993 Philipp
5,271,543 A 12/1993 Grant et al.
5,271,544 A 12/1993 Fox et al.
RE34,519 E 1/1994 Fox et al.
5,275,323 A 1/1994 Schulze et al.
5,275,608 A 1/1994 Forman et al.
5,279,416 A 1/1994 Malec et al.
5,281,216 A 1/1994 Klicek
5,282,806 A 2/1994 Haber et al.
5,282,829 A 2/1994 Hermes
5,284,128 A 2/1994 Hart
5,285,945 A 2/1994 Brinkerhoff et al.
5,289,963 A 3/1994 McGarry et al.
5,292,053 A 3/1994 Bilotti et al.
5,297,714 A 3/1994 Kramer
5,304,204 A 4/1994 Bregen
5,307,976 A 5/1994 Olson et al.
5,309,927 A 5/1994 Welch
5,312,023 A 5/1994 Green et al.
5,312,024 A 5/1994 Grant et al.
5,312,329 A 5/1994 Beaty et al.
5,314,424 A 5/1994 Nicholas
5,314,445 A 5/1994 Heidmueller née Degwitz et al.
5,318,221 A 6/1994 Green et al.
5,330,487 A 7/1994 Thornton et al.
5,330,502 A 7/1994 Hassler et al.
5,332,142 A 7/1994 Robinson et al.
5,333,422 A 8/1994 Warren et al.
5,333,772 A 8/1994 Rothfuss et al.
5,334,183 A 8/1994 Wuchinich
5,336,232 A 8/1994 Green et al.
5,339,799 A 8/1994 Kami et al.
5,341,724 A 8/1994 Vatel
5,341,810 A 8/1994 Dardel
5,342,381 A 8/1994 Tidemand
5,342,395 A 8/1994 Jarrett et al.
5,342,396 A 8/1994 Cook
5,344,060 A 9/1994 Gravener et al.
5,346,504 A 9/1994 Ortiz et al.
5,348,259 A 9/1994 Blanco et al.
5,350,388 A 9/1994 Epstein
5,350,391 A 9/1994 Iacovelli
5,350,400 A 9/1994 Esposito et al.
5,352,229 A 10/1994 Goble et al.
5,352,235 A 10/1994 Koros et al.
5,352,238 A 10/1994 Green et al.
5,354,303 A 10/1994 Spaeth et al.
5,356,006 A 10/1994 Alpern et al.
5,358,506 A 10/1994 Green et al.
5,358,510 A 10/1994 Luscombe et al.
5,359,231 A 10/1994 Flowers et al.
D352,780 S 11/1994 Glaeser et al.
5,360,428 A 11/1994 Hutchinson, Jr.
5,364,001 A 11/1994 Bryan
5,364,003 A 11/1994 Williamson, IV
5,366,133 A 11/1994 Geiste
5,366,134 A 11/1994 Green et al.
5,366,479 A 11/1994 McGarry et al.
5,368,015 A 11/1994 Wilk
5,368,592 A 11/1994 Stern et al.
5,370,645 A 12/1994 Klicek et al.
5,372,596 A 12/1994 Klicek et al.
5,372,602 A 12/1994 Burke
5,374,277 A 12/1994 Hassler
5,376,095 A 12/1994 Ortiz
5,379,933 A 1/1995 Green et al.
5,381,782 A 1/1995 DeLaRama et al.
5,382,247 A 1/1995 Cimino et al.
5,383,880 A 1/1995 Hooven
5,383,881 A 1/1995 Green et al.
5,383,888 A 1/1995 Zvenyatsky et al.
5,383,895 A 1/1995 Holmes et al.
5,389,098 A 2/1995 Tsuruta et al.
5,389,104 A 2/1995 Hahnen et al.
5,391,180 A 2/1995 Tovey et al.
5,392,979 A 2/1995 Green et al.
5,395,030 A 3/1995 Kuramoto et al.
5,395,033 A 3/1995 Byrne et al.
5,395,034 A 3/1995 Allen et al.
5,395,312 A 3/1995 Desai
5,395,384 A 3/1995 Duthoit
5,397,046 A 3/1995 Savage et al.
5,397,324 A 3/1995 Carroll et al.
5,403,312 A 4/1995 Yates et al.
5,405,072 A 4/1995 Zlock et al.
5,405,073 A 4/1995 Porter
5,405,344 A 4/1995 Williamson et al.
5,405,360 A 4/1995 Tovey
5,407,293 A 4/1995 Crainich
5,409,498 A 4/1995 Braddock et al.
5,411,508 A 5/1995 Bessler et al.
5,413,267 A 5/1995 Solyntjes et al.
5,413,268 A 5/1995 Green et al.
5,413,272 A 5/1995 Green et al.
5,413,573 A 5/1995 Koivukangas
5,415,334 A 5/1995 Williamson, IV et al.
5,415,335 A 5/1995 Knodell, Jr.
5,417,203 A 5/1995 Tovey et al.
5,417,361 A 5/1995 Williamson, IV
5,421,829 A 6/1995 Olichney et al.
5,422,567 A 6/1995 Matsunaga
5,423,471 A 6/1995 Mastri et al.
5,423,809 A 6/1995 Klicek
5,425,745 A 6/1995 Green et al.
5,431,322 A 7/1995 Green et al.
5,431,654 A 7/1995 Nic
5,431,668 A 7/1995 Burbank, III et al.
5,433,721 A 7/1995 Hooven et al.
5,437,681 A 8/1995 Meade et al.
5,438,302 A 8/1995 Goble
5,439,155 A 8/1995 Viola
5,439,156 A 8/1995 Grant et al.
5,439,479 A 8/1995 Schichman et al.
5,441,191 A 8/1995 Linden
5,441,193 A 8/1995 Gravener
5,441,483 A 8/1995 Avitall
5,441,494 A 8/1995 Ortiz
5,444,113 A 8/1995 Sinclair et al.
5,445,155 A 8/1995 Sieben
5,445,304 A 8/1995 Plyley et al.
5,445,644 A 8/1995 Pietrafitta et al.
5,447,417 A 9/1995 Kuhl et al.
5,447,513 A 9/1995 Davison et al.
5,449,355 A 9/1995 Rhum et al.
5,449,365 A 9/1995 Green et al.
5,449,370 A 9/1995 Vaitekunas
5,452,836 A 9/1995 Huitema et al.
5,452,837 A 9/1995 Williamson, IV et al.
5,454,378 A 10/1995 Palmer et al.
5,454,827 A 10/1995 Aust et al.
5,456,401 A 10/1995 Green et al.
5,458,579 A 10/1995 Chodorow et al.
5,462,215 A 10/1995 Viola et al.
5,464,013 A 11/1995 Lemelson
5,464,144 A 11/1995 Guy et al.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,464,300 A 11/1995 Crainich
5,465,894 A 11/1995 Clark et al.
5,465,895 A 11/1995 Knodel et al.
5,465,896 A 11/1995 Allen et al.
5,466,020 A 11/1995 Page et al.
5,467,911 A 11/1995 Tsuruta et al.
5,468,253 A 11/1995 Bezwada et al.
5,470,006 A 11/1995 Rodak
5,470,007 A 11/1995 Plyley et al.
5,470,009 A 11/1995 Rodak
5,470,010 A 11/1995 Rothfuss et al.
5,472,132 A 12/1995 Savage et al.
5,472,442 A 12/1995 Klicek
5,473,204 A 12/1995 Temple
5,474,057 A 12/1995 Makower et al.
5,474,566 A 12/1995 Alesi et al.
5,476,206 A 12/1995 Green et al.
5,476,479 A 12/1995 Green et al.
5,478,003 A 12/1995 Green et al.
5,478,354 A 12/1995 Tovey et al.
5,480,089 A 1/1996 Blewett
5,480,409 A 1/1996 Riza
5,482,197 A 1/1996 Green et al.
5,484,095 A 1/1996 Green et al.
5,484,398 A 1/1996 Stoddard
5,484,451 A 1/1996 Akopov et al.
5,485,947 A 1/1996 Olson et al.
5,485,952 A 1/1996 Fontayne
5,487,499 A 1/1996 Sorrentino et al.
5,487,500 A 1/1996 Knodel et al.
5,489,058 A 2/1996 Plyley et al.
5,489,256 A 2/1996 Adair
5,496,312 A 3/1996 Klicek
5,496,317 A 3/1996 Goble et al.
5,497,933 A 3/1996 DeFonzo et al.
5,503,320 A 4/1996 Webster et al.
5,503,635 A 4/1996 Sauer et al.
5,503,638 A 4/1996 Cooper et al.
5,505,363 A 4/1996 Green et al.
5,507,426 A 4/1996 Young et al.
5,509,596 A 4/1996 Green et al.
5,509,916 A 4/1996 Taylor
5,511,564 A 4/1996 Wilk
5,514,129 A 5/1996 Smith
5,514,157 A 5/1996 Nicholas et al.
5,518,163 A 5/1996 Hooven
5,518,164 A 5/1996 Hooven
5,520,678 A 5/1996 Heckele et al.
5,520,700 A 5/1996 Beyar et al.
5,522,817 A 6/1996 Sander et al.
5,527,320 A 6/1996 Carruthers et al.
5,529,235 A 6/1996 Boiarski et al.
D372,086 S 7/1996 Grasso et al.
5,531,305 A 7/1996 Roberts et al.
5,531,744 A 7/1996 Nardella et al.
5,533,521 A 7/1996 Granger
5,533,581 A 7/1996 Barth et al.
5,533,661 A 7/1996 Main et al.
5,535,934 A 7/1996 Boiarski et al.
5,535,935 A 7/1996 Vidal et al.
5,535,937 A 7/1996 Boiarski et al.
5,540,375 A 7/1996 Bolanos et al.
5,541,376 A 7/1996 Ladtkow et al.
5,542,594 A 8/1996 McKean et al.
5,542,949 A 8/1996 Yoon
5,543,119 A 8/1996 Sutter et al.
5,547,117 A 8/1996 Hamblin et al.
5,549,621 A 8/1996 Bessler et al.
5,549,628 A 8/1996 Cooper et al.
5,549,637 A 8/1996 Crainich
5,551,622 A 9/1996 Yoon
5,553,675 A 9/1996 Pitzen et al.
5,553,765 A 9/1996 Knodel et al.
5,554,148 A 9/1996 Aebischer et al.
5,554,169 A 9/1996 Green et al.
5,556,416 A 9/1996 Clark et al.
5,558,665 A 9/1996 Kieturakis
5,558,671 A 9/1996 Yates
5,560,530 A 10/1996 Bolanos et al.
5,560,532 A 10/1996 DeFonzo et al.
5,562,239 A 10/1996 Boiarski et al.
5,562,241 A 10/1996 Knodel et al.
5,562,682 A 10/1996 Oberlin et al.
5,562,690 A 10/1996 Green et al.
5,562,701 A 10/1996 Huitema et al.
5,562,702 A 10/1996 Huitema et al.
5,564,615 A 10/1996 Bishop et al.
5,569,161 A 10/1996 Ebling et al.
5,569,270 A 10/1996 Weng
5,569,284 A 10/1996 Young et al.
5,571,090 A 11/1996 Sherts
5,571,100 A 11/1996 Goble et al.
5,571,116 A 11/1996 Bolanos et al.
5,571,285 A 11/1996 Chow et al.
5,573,543 A 11/1996 Akopov et al.
5,574,431 A 11/1996 McKeown et al.
5,575,054 A 11/1996 Klinzing et al.
5,575,789 A 11/1996 Bell et al.
5,575,799 A 11/1996 Bolanos et al.
5,575,803 A * 11/1996 Cooper et al. 606/151
5,575,805 A 11/1996 Li
5,577,654 A 11/1996 Bishop
5,579,978 A 12/1996 Green et al.
5,580,067 A 12/1996 Hamblin et al.
5,582,611 A 12/1996 Tsuruta et al.
5,582,617 A 12/1996 Klieman et al.
5,584,425 A 12/1996 Savage et al.
5,586,711 A 12/1996 Plyley et al.
5,588,579 A 12/1996 Schnut et al.
5,588,580 A 12/1996 Paul et al.
5,588,581 A 12/1996 Conlon et al.
5,591,170 A 1/1997 Spievack et al.
5,591,187 A 1/1997 Dekel
5,597,107 A 1/1997 Knodel et al.
5,599,151 A 2/1997 Daum et al.
5,599,344 A 2/1997 Paterson
5,599,350 A 2/1997 Schulze et al.
5,599,852 A 2/1997 Scopelianos et al.
5,601,224 A 2/1997 Bishop et al.
5,603,443 A 2/1997 Clark et al.
5,605,272 A 2/1997 Witt et al.
5,605,273 A 2/1997 Hamblin et al.
5,607,094 A 3/1997 Clark et al.
5,607,095 A 3/1997 Smith et al.
5,607,433 A 3/1997 Polla et al.
5,607,450 A 3/1997 Zvenyatsky et al.
5,609,285 A 3/1997 Grant et al.
5,609,601 A 3/1997 Kolesa et al.
5,611,709 A 3/1997 McAnulty
5,613,966 A 3/1997 Makower et al.
5,615,820 A 4/1997 Viola
5,618,294 A 4/1997 Aust et al.
5,618,303 A 4/1997 Marlow et al.
5,618,307 A 4/1997 Donlon et al.
5,619,992 A 4/1997 Guthrie et al.
5,620,289 A 4/1997 Curry
5,620,452 A 4/1997 Yoon
5,624,452 A 4/1997 Yates
5,626,587 A 5/1997 Bishop et al.
5,626,595 A 5/1997 Sklar et al.
5,628,446 A 5/1997 Geiste et al.
5,628,743 A 5/1997 Cimino
5,628,745 A 5/1997 Bek
5,630,539 A 5/1997 Plyley et al.
5,630,540 A 5/1997 Blewett
5,630,541 A 5/1997 Williamson, IV et al.
5,630,782 A 5/1997 Adair
5,632,432 A 5/1997 Schulze et al.
5,632,433 A 5/1997 Grant et al.
5,634,584 A 6/1997 Okorocha et al.
5,636,779 A 6/1997 Palmer
5,636,780 A 6/1997 Green et al.
5,639,008 A 6/1997 Gallagher et al.
5,643,291 A 7/1997 Pier et al.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,645,209 A 7/1997 Green et al.
5,647,526 A 7/1997 Green et al.
5,647,869 A 7/1997 Goble et al.
5,649,937 A 7/1997 Bito et al.
5,651,491 A 7/1997 Heaton et al.
5,653,373 A 8/1997 Green et al.
5,653,374 A 8/1997 Young et al.
5,653,677 A 8/1997 Okada et al.
5,653,721 A 8/1997 Knodel et al.
5,655,698 A 8/1997 Yoon
5,657,921 A 8/1997 Young et al.
5,658,281 A 8/1997 Heard
5,658,300 A 8/1997 Bito et al.
5,658,307 A 8/1997 Exconde
5,662,258 A 9/1997 Knodel et al.
5,662,260 A 9/1997 Yoon
5,662,662 A 9/1997 Bishop et al.
5,665,085 A 9/1997 Nardella
5,667,517 A 9/1997 Hooven
5,667,526 A 9/1997 Levin
5,667,527 A 9/1997 Cook
5,669,544 A 9/1997 Schulze et al.
5,669,904 A 9/1997 Platt, Jr. et al.
5,669,907 A 9/1997 Platt, Jr. et al.
5,669,918 A 9/1997 Balazs et al.
5,673,840 A 10/1997 Schulze et al.
5,673,841 A 10/1997 Schulze et al.
5,673,842 A 10/1997 Bittner et al.
5,674,286 A * 10/1997 D'Alessio et al. 424/423
5,678,748 A 10/1997 Plyley et al.
5,680,981 A 10/1997 Mililli et al.
5,680,982 A 10/1997 Schulze et al.
5,680,983 A 10/1997 Plyley et al.
5,683,349 A 11/1997 Makower et al.
5,685,474 A 11/1997 Seeber
5,686,090 A 11/1997 Schilder et al.
5,688,270 A 11/1997 Yates et al.
5,690,269 A 11/1997 Bolanos et al.
5,692,668 A 12/1997 Schulze et al.
5,693,020 A 12/1997 Rauh
5,693,042 A 12/1997 Boiarski et al.
5,693,051 A 12/1997 Schulze et al.
5,695,494 A 12/1997 Becker
5,695,502 A 12/1997 Pier et al.
5,695,504 A 12/1997 Gifford, III et al.
5,695,524 A 12/1997 Kelley et al.
5,697,543 A 12/1997 Burdorff
5,697,943 A 12/1997 Sauer et al.
5,700,270 A 12/1997 Peyser et al.
5,702,387 A 12/1997 Arts et al.
5,702,408 A 12/1997 Wales et al.
5,702,409 A 12/1997 Rayburn et al.
5,704,087 A 1/1998 Strub
5,704,534 A 1/1998 Huitema et al.
5,706,997 A 1/1998 Green et al.
5,706,998 A 1/1998 Plyley et al.
5,707,392 A 1/1998 Kortenbach
5,709,334 A 1/1998 Sorrentino et al.
5,709,680 A 1/1998 Yates et al.
5,709,706 A 1/1998 Kienzle et al.
5,711,472 A 1/1998 Bryan
5,713,128 A 2/1998 Schrenk et al.
5,713,505 A 2/1998 Huitema
5,713,895 A 2/1998 Lontine et al.
5,713,896 A 2/1998 Nardella
5,713,920 A 2/1998 Bezwada et al.
5,715,987 A 2/1998 Kelley et al.
5,715,988 A 2/1998 Palmer
5,716,366 A 2/1998 Yates
5,718,359 A 2/1998 Palmer et al.
5,718,360 A 2/1998 Green et al.
5,718,548 A 2/1998 Cotellessa
5,720,744 A 2/1998 Eggleston et al.
D393,067 S 3/1998 Geary et al.
5,725,536 A 3/1998 Oberlin et al.
5,725,554 A 3/1998 Simon et al.
5,728,110 A 3/1998 Vidal et al.
5,728,121 A 3/1998 Bimbo et al.
5,730,758 A 3/1998 Allgeyer
5,732,821 A 3/1998 Stone et al.
5,732,871 A 3/1998 Clark et al.
5,732,872 A 3/1998 Bolduc et al.
5,733,308 A 3/1998 Daugherty et al.
5,735,445 A 4/1998 Vidal et al.
5,735,848 A 4/1998 Yates et al.
5,735,874 A 4/1998 Measamer et al.
5,738,474 A 4/1998 Blewett
5,738,648 A 4/1998 Lands et al.
5,743,456 A 4/1998 Jones et al.
5,747,953 A 5/1998 Philipp
5,749,889 A 5/1998 Bacich et al.
5,749,893 A 5/1998 Vidal et al.
5,752,644 A 5/1998 Bolanos et al.
5,752,965 A 5/1998 Francis et al.
5,755,717 A 5/1998 Yates et al.
5,758,814 A 6/1998 Gallagher et al.
5,762,255 A 6/1998 Chrisman et al.
5,762,256 A 6/1998 Mastri et al.
5,766,188 A 6/1998 Igaki
5,766,205 A 6/1998 Zvenyatsky et al.
5,769,892 A * 6/1998 Kingwell 606/151
5,772,379 A 6/1998 Evensen
5,772,578 A 6/1998 Heimberger et al.
5,772,659 A 6/1998 Becker et al.
5,776,130 A 7/1998 Buysse et al.
5,779,130 A 7/1998 Alesi et al.
5,779,131 A 7/1998 Knodel et al.
5,779,132 A 7/1998 Knodel et al.
5,782,396 A 7/1998 Mastri et al.
5,782,397 A 7/1998 Koukline
5,782,749 A 7/1998 Riza
5,782,859 A 7/1998 Nicholas et al.
5,784,934 A 7/1998 Izumisawa
5,785,232 A 7/1998 Vidal et al.
5,785,647 A 7/1998 Tompkins et al.
5,787,897 A 8/1998 Kieturakis
5,792,135 A 8/1998 Madhani et al.
5,792,165 A 8/1998 Klieman et al.
5,794,834 A 8/1998 Hamblin et al.
5,796,188 A 8/1998 Bays
5,797,536 A 8/1998 Smith et al.
5,797,537 A 8/1998 Oberlin et al.
5,797,538 A 8/1998 Heaton et al.
5,797,906 A 8/1998 Rhum et al.
5,797,959 A 8/1998 Castro et al.
5,799,857 A 9/1998 Robertson et al.
5,800,379 A 9/1998 Edwards
5,806,676 A 9/1998 Wasgien
5,807,376 A 9/1998 Viola et al.
5,807,378 A 9/1998 Jensen et al.
5,807,393 A 9/1998 Williamson, IV et al.
5,809,441 A 9/1998 McKee
5,810,721 A 9/1998 Mueller et al.
5,810,811 A 9/1998 Yates et al.
5,810,846 A 9/1998 Virnich et al.
5,810,855 A 9/1998 Rayburn et al.
5,813,813 A 9/1998 Daum et al.
5,814,055 A 9/1998 Knodel et al.
5,814,057 A 9/1998 Oi et al.
5,816,471 A 10/1998 Plyley et al.
5,817,084 A 10/1998 Jensen
5,817,091 A 10/1998 Nardella et al.
5,817,093 A 10/1998 Williamson, IV et al.
5,817,109 A 10/1998 McGarry et al.
5,817,119 A 10/1998 Klieman et al.
5,820,009 A 10/1998 Melling et al.
5,823,066 A 10/1998 Huitema et al.
5,826,776 A 10/1998 Schulze et al.
5,827,271 A 10/1998 Buysse et al.
5,827,298 A 10/1998 Hart et al.
5,829,662 A 11/1998 Allen et al.
5,833,690 A 11/1998 Yates et al.
5,833,695 A 11/1998 Yoon
5,833,696 A 11/1998 Whitfield et al.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,836,503 A 11/1998 Ehrenfels et al.
5,836,960 A 11/1998 Kolesa et al.
5,839,639 A 11/1998 Sauer et al.
5,843,021 A 12/1998 Edwards et al.
5,843,096 A 12/1998 Igaki et al.
5,843,122 A 12/1998 Riza
5,843,132 A 12/1998 Ilvento
5,846,254 A 12/1998 Schulze et al.
5,849,011 A 12/1998 Jones et al.
5,849,023 A 12/1998 Mericle
5,855,311 A 1/1999 Hamblin et al.
5,855,583 A 1/1999 Wang et al.
5,860,581 A 1/1999 Robertson et al.
5,860,975 A 1/1999 Goble et al.
5,865,361 A 2/1999 Milliman et al.
5,868,760 A 2/1999 McGuckin, Jr.
5,871,135 A 2/1999 Williamson, IV et al.
5,873,885 A 2/1999 Weidenbenner
5,876,401 A 3/1999 Schulze et al.
5,878,193 A 3/1999 Wang et al.
5,878,937 A 3/1999 Green et al.
5,878,938 A 3/1999 Bittner et al.
5,891,160 A 4/1999 Williamson, IV et al.
5,893,506 A 4/1999 Powell
5,893,835 A 4/1999 Witt et al.
5,894,979 A 4/1999 Powell
5,897,552 A 4/1999 Edwards et al.
5,897,562 A 4/1999 Bolanos et al.
5,899,914 A 5/1999 Zirps et al.
5,901,895 A 5/1999 Heaton et al.
5,902,312 A 5/1999 Frater et al.
5,904,693 A 5/1999 Dicesare et al.
5,906,625 A 5/1999 Bito et al.
5,908,402 A 6/1999 Blythe
5,908,427 A 6/1999 McKean et al.
5,911,353 A 6/1999 Bolanos et al.
5,915,616 A 6/1999 Viola et al.
5,918,791 A 7/1999 Sorrentino et al.
5,919,198 A 7/1999 Graves, Jr. et al.
5,921,956 A 7/1999 Grinberg et al.
5,928,256 A 7/1999 Riza
5,931,847 A 8/1999 Bittner et al.
5,931,853 A 8/1999 McEwen et al.
5,937,951 A 8/1999 Izuchukwu et al.
5,938,667 A 8/1999 Peyser et al.
5,941,442 A 8/1999 Geiste et al.
5,944,172 A 8/1999 Hannula
5,944,715 A 8/1999 Goble et al.
5,947,984 A 9/1999 Whipple
5,948,030 A 9/1999 Miller et al.
5,951,552 A 9/1999 Long et al.
5,951,574 A 9/1999 Stefanchik et al.
5,951,581 A 9/1999 Saadat et al.
5,954,259 A 9/1999 Viola et al.
5,964,774 A 10/1999 McKean et al.
5,971,916 A 10/1999 Koren
5,984,949 A 11/1999 Levin
5,988,479 A 11/1999 Palmer
5,997,528 A 12/1999 Bisch et al.
5,997,552 A 12/1999 Person et al.
6,003,517 A 12/1999 Sheffield et al.
6,004,319 A 12/1999 Goble et al.
6,010,054 A 1/2000 Johnson et al.
6,010,513 A 1/2000 Törmälä et al.
6,012,494 A 1/2000 Balazs
6,013,076 A 1/2000 Goble et al.
6,015,406 A 1/2000 Goble et al.
6,017,322 A 1/2000 Snoke et al.
6,017,356 A 1/2000 Frederick et al.
6,022,352 A 2/2000 Vandewalle
6,024,741 A 2/2000 Williamson, IV et al.
6,024,748 A 2/2000 Manzo et al.
6,027,501 A 2/2000 Goble et al.
6,032,849 A 3/2000 Mastri et al.
6,033,378 A 3/2000 Lundquist et al.
6,033,399 A 3/2000 Gines
6,033,427 A 3/2000 Lee
6,039,733 A 3/2000 Buysse et al.
6,039,734 A 3/2000 Goble
6,042,601 A 3/2000 Smith
6,045,560 A 4/2000 McKean et al.
6,047,861 A 4/2000 Vidal et al.
6,050,472 A 4/2000 Shibata
6,050,990 A 4/2000 Tankovich et al.
6,050,996 A 4/2000 Schmaltz et al.
6,053,390 A 4/2000 Green et al.
6,053,922 A 4/2000 Krause et al.
RE36,720 E 5/2000 Green et al.
6,056,735 A 5/2000 Okada et al.
6,056,746 A 5/2000 Goble et al.
6,062,360 A 5/2000 Shields
6,063,097 A 5/2000 Oi et al.
6,063,098 A 5/2000 Houser et al.
6,065,919 A 5/2000 Peck
6,066,132 A 5/2000 Chen et al.
6,068,627 A 5/2000 Orszulak et al.
6,071,233 A 6/2000 Ishikawa et al.
6,074,386 A 6/2000 Goble et al.
6,074,401 A 6/2000 Gardiner et al.
6,077,286 A 6/2000 Cuschieri et al.
6,079,606 A 6/2000 Milliman et al.
6,082,577 A 7/2000 Coates et al.
6,083,191 A 7/2000 Rose
6,083,234 A 7/2000 Nicholas et al.
6,083,242 A 7/2000 Cook
6,086,544 A 7/2000 Hibner et al.
6,086,600 A 7/2000 Kortenbach
6,090,106 A 7/2000 Goble et al.
6,093,186 A 7/2000 Goble
6,099,537 A 8/2000 Sugai et al.
6,099,551 A 8/2000 Gabbay
6,102,271 A 8/2000 Longo et al.
6,109,500 A 8/2000 Alli et al.
6,117,148 A 9/2000 Ravo et al.
6,117,158 A 9/2000 Measamer et al.
6,119,913 A 9/2000 Adams et al.
6,120,433 A 9/2000 Mizuno et al.
6,123,241 A 9/2000 Walter et al.
H1904 H 10/2000 Yates et al.
6,126,058 A 10/2000 Adams et al.
6,126,670 A 10/2000 Walker et al.
6,131,789 A 10/2000 Schulze et al.
6,131,790 A 10/2000 Piraka
6,132,368 A 10/2000 Cooper
6,139,546 A 10/2000 Koenig et al.
6,149,660 A 11/2000 Laufer et al.
6,152,935 A 11/2000 Kammerer et al.
6,155,473 A 12/2000 Tompkins et al.
6,156,056 A 12/2000 Kearns et al.
6,159,146 A 12/2000 El Gazayerli
6,159,200 A 12/2000 Verdura et al.
6,159,224 A 12/2000 Yoon
6,162,208 A 12/2000 Hipps
6,165,175 A 12/2000 Wampler et al.
6,165,184 A 12/2000 Verdura et al.
6,165,188 A 12/2000 Saadat et al.
6,168,605 B1 1/2001 Measamer et al.
6,171,316 B1 1/2001 Kovac et al.
6,171,330 B1 1/2001 Benchetrit
6,174,308 B1 1/2001 Goble et al.
6,174,309 B1 1/2001 Wrublewski et al.
6,179,195 B1 1/2001 Adams et al.
6,179,776 B1 1/2001 Adams et al.
6,181,105 B1 1/2001 Cutolo et al.
6,182,673 B1 2/2001 Kindermann et al.
6,187,003 B1 2/2001 Buysse et al.
6,190,386 B1 2/2001 Rydell
6,193,129 B1 2/2001 Bittner et al.
6,197,042 B1 3/2001 Ginn et al.
6,200,330 B1 3/2001 Benderev et al.
6,202,914 B1 3/2001 Geiste et al.
6,206,897 B1 3/2001 Jamiolkowski et al.
6,210,403 B1 4/2001 Klicek
6,213,999 B1 4/2001 Platt, Jr. et al.

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,214,028	B1	4/2001	Yoon et al.
6,220,368	B1	4/2001	Ark et al.
6,223,835	B1	5/2001	Habedank et al.
6,224,617	B1	5/2001	Saadat et al.
6,228,081	B1	5/2001	Goble
6,228,083	B1	5/2001	Lands et al.
6,228,084	B1	5/2001	Kirwan, Jr.
6,231,565	B1	5/2001	Tovey et al.
6,234,178	B1	5/2001	Goble et al.
6,241,139	B1	6/2001	Milliman et al.
6,241,140	B1	6/2001	Adams et al.
6,241,723	B1	6/2001	Heim et al.
6,248,117	B1	6/2001	Blatter
6,249,076	B1	6/2001	Madden et al.
6,250,532	B1	6/2001	Green et al.
6,258,107	B1	7/2001	Balázs et al.
6,261,286	B1	7/2001	Goble et al.
6,264,086	B1	7/2001	McGuckin, Jr.
6,264,087	B1	7/2001	Whitman
6,270,508	B1	8/2001	Klieman et al.
6,273,876	B1	8/2001	Klima et al.
6,273,897	B1	8/2001	Dalessandro et al.
6,277,114	B1	8/2001	Bullivant et al.
6,293,942	B1	9/2001	Goble et al.
6,296,640	B1	10/2001	Wampler et al.
6,302,311	B1	10/2001	Adams et al.
6,305,891	B1	10/2001	Burlingame
6,306,134	B1	10/2001	Goble et al.
6,306,149	B1	10/2001	Meade
6,309,403	B1	10/2001	Minor et al.
6,315,184	B1	11/2001	Whitman
6,320,123	B1	11/2001	Reimers
6,322,494	B1	11/2001	Bullivant et al.
6,324,339	B1	11/2001	Hudson et al.
6,325,799	B1	12/2001	Goble
6,325,810	B1	12/2001	Hamilton et al.
6,330,965	B1	12/2001	Milliman et al.
6,331,181	B1	12/2001	Tierney et al.
6,331,761	B1	12/2001	Kumar et al.
6,333,029	B1	12/2001	Vyakarnam et al.
6,334,860	B1	1/2002	Dorn
6,334,861	B1	1/2002	Chandler et al.
6,336,926	B1	1/2002	Goble
6,338,737	B1	1/2002	Toledano
6,343,731	B1	2/2002	Adams et al.
6,346,077	B1	2/2002	Taylor et al.
6,352,503	B1	3/2002	Matsui et al.
6,352,532	B1	3/2002	Kramer et al.
6,355,699	B1	3/2002	Vyakarnam et al.
6,358,224	B1	3/2002	Tims et al.
6,364,877	B1	4/2002	Goble et al.
6,364,888	B1	4/2002	Niemeyer et al.
6,370,981	B2	4/2002	Watarai
6,373,152	B1	4/2002	Wang et al.
6,383,201	B1	5/2002	Dong
6,387,113	B1	5/2002	Hawkins et al.
6,387,114	B2	5/2002	Adams
6,391,038	B2	5/2002	Vargas et al.
6,398,781	B1	6/2002	Goble et al.
6,398,797	B2	6/2002	Bombard et al.
6,402,766	B2	6/2002	Bowman et al.
6,406,440	B1	6/2002	Stefanchik
6,409,724	B1	6/2002	Penny et al.
H2037	H	7/2002	Yates et al.
6,413,274	B1	7/2002	Pedros
6,416,486	B1	7/2002	Wampler
6,416,509	B1	7/2002	Goble et al.
6,419,695	B1	7/2002	Gabbay
RE37,814	E	8/2002	Allgeyer
6,428,070	B1	8/2002	Takanashi et al.
6,429,611	B1	8/2002	Li
6,436,097	B1	8/2002	Nardella
6,436,107	B1	8/2002	Wang et al.
6,436,110	B2	8/2002	Bowman et al.
6,436,122	B1	8/2002	Frank et al.
6,439,439	B1	8/2002	Rickard et al.
6,439,446	B1	8/2002	Perry et al.
6,440,146	B2	8/2002	Nicholas et al.
6,443,973	B1	9/2002	Whitman
6,447,518	B1	9/2002	Krause et al.
6,450,391	B1	9/2002	Kayan et al.
6,450,989	B2	9/2002	Dubrul et al.
6,454,781	B1	9/2002	Witt et al.
6,468,275	B1	10/2002	Wampler et al.
6,471,106	B1	10/2002	Reining
6,478,210	B2	11/2002	Adams et al.
6,482,200	B2	11/2002	Shippert
6,485,490	B2	11/2002	Wampler et al.
6,485,667	B1	11/2002	Tan
6,488,196	B1	12/2002	Fenton, Jr.
6,488,197	B1	12/2002	Whitman
6,491,201	B1	12/2002	Whitman
6,491,690	B1	12/2002	Goble et al.
6,491,701	B2	12/2002	Tierney et al.
6,492,785	B1	12/2002	Kasten et al.
6,494,896	B1	12/2002	D'Alessio et al.
6,500,176	B1	12/2002	Truckai et al.
6,500,194	B2	12/2002	Benderev et al.
6,503,257	B2	1/2003	Grant et al.
6,503,259	B2	1/2003	Huxel et al.
6,505,768	B2	1/2003	Whitman
6,510,854	B2	1/2003	Goble
6,511,468	B1	1/2003	Cragg et al.
6,517,528	B1	2/2003	Pantages et al.
6,517,535	B2	2/2003	Edwards
6,517,565	B1	2/2003	Whitman et al.
6,517,566	B1	2/2003	Hovland et al.
6,522,101	B2	2/2003	Malackowski
6,527,785	B2	3/2003	Sancoff et al.
6,533,157	B1	3/2003	Whitman
6,533,784	B2	3/2003	Truckai et al.
6,535,764	B2	3/2003	Imran et al.
6,543,456	B1	4/2003	Freeman
6,545,384	B1	4/2003	Pelrine et al.
6,547,786	B1	4/2003	Goble
6,550,546	B2	4/2003	Thurler et al.
6,551,333	B2	4/2003	Kuhns et al.
6,554,861	B2	4/2003	Knox et al.
6,558,379	B1	5/2003	Batchelor et al.
6,565,560	B1	5/2003	Goble et al.
6,569,085	B2	5/2003	Kortenbach et al.
6,569,171	B2	5/2003	DeGuillebon et al.
6,578,751	B2	6/2003	Hartwick
6,582,427	B1	6/2003	Goble et al.
6,583,533	B2	6/2003	Pelrine et al.
6,585,144	B2	7/2003	Adams et al.
6,588,643	B2	7/2003	Bolduc et al.
6,589,164	B1	7/2003	Flaherty
6,592,538	B1	7/2003	Hotchkiss et al.
6,592,597	B2	7/2003	Grant et al.
6,596,296	B1 *	7/2003	Nelson et al. 424/426
6,596,304	B1	7/2003	Bayon et al.
6,596,432	B2	7/2003	Kawakami et al.
D478,665	S	8/2003	Isaacs et al.
D478,986	S	8/2003	Johnston et al.
6,601,749	B2	8/2003	Sullivan et al.
6,602,252	B2	8/2003	Mollenauer
6,602,262	B2	8/2003	Griego et al.
6,605,078	B2	8/2003	Adams
6,605,669	B2	8/2003	Awokola et al.
6,607,475	B2	8/2003	Doyle et al.
6,616,686	B2	9/2003	Coleman et al.
6,619,529	B2	9/2003	Green et al.
6,620,166	B1	9/2003	Wenstrom, Jr. et al.
6,626,834	B2	9/2003	Dunne et al.
6,629,630	B2	10/2003	Adams
6,629,974	B2	10/2003	Penny et al.
6,629,988	B2	10/2003	Weadock
6,636,412	B2	10/2003	Smith
6,638,108	B2	10/2003	Tachi
6,638,285	B2	10/2003	Gabbay
6,638,297	B1	10/2003	Huitema
RE38,335	E	11/2003	Aust et al.
6,641,528	B2	11/2003	Torii

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,644,532 B2 11/2003 Green et al.
6,645,201 B1 11/2003 Utley et al.
6,646,307 B1 11/2003 Yu et al.
6,648,816 B2 11/2003 Irion et al.
6,652,595 B1 11/2003 Nicolo
D484,243 S 12/2003 Ryan et al.
D484,595 S 12/2003 Ryan et al.
D484,596 S 12/2003 Ryan et al.
6,656,177 B2 12/2003 Truckai et al.
6,656,193 B2 12/2003 Grant et al.
6,663,641 B1 12/2003 Kovac et al.
6,666,854 B1 12/2003 Lange
6,666,875 B1 12/2003 Sakurai et al.
6,667,825 B2 12/2003 Lu et al.
6,669,073 B2 12/2003 Milliman et al.
6,671,185 B2 12/2003 Duval
D484,977 S 1/2004 Ryan et al.
6,676,660 B2 1/2004 Wampler et al.
6,679,269 B2 1/2004 Swanson
6,679,410 B2 1/2004 Würsch et al.
6,681,978 B2 1/2004 Geiste et al.
6,681,979 B2 1/2004 Whitman
6,682,527 B2 1/2004 Strul
6,682,528 B2 1/2004 Frazier et al.
6,685,727 B2 2/2004 Fisher et al.
6,689,153 B1 2/2004 Skiba
6,692,507 B2 2/2004 Pugsley et al.
6,695,198 B2 2/2004 Adams et al.
6,695,199 B2 2/2004 Whitman
6,698,643 B2 3/2004 Whitman
6,699,235 B2 3/2004 Wallace et al.
6,704,210 B1 3/2004 Myers
6,705,503 B1 3/2004 Pedicini et al.
6,709,445 B2 3/2004 Boebel et al.
6,712,773 B1 3/2004 Viola
6,716,223 B2 4/2004 Leopold et al.
6,716,232 B1 4/2004 Vidal et al.
6,716,233 B1 4/2004 Whitman
6,722,552 B2 4/2004 Fenton, Jr.
6,723,087 B2 4/2004 O'Neill et al.
6,723,091 B2 4/2004 Goble et al.
6,726,697 B2 4/2004 Nicholas et al.
6,729,119 B2 5/2004 Schnipke et al.
6,736,825 B2 5/2004 Blatter et al.
6,736,854 B2 5/2004 Vadurro et al.
6,740,030 B2 5/2004 Martone et al.
6,747,121 B2 6/2004 Gogolewski
6,749,560 B1 6/2004 Konstorum et al.
6,752,768 B2 6/2004 Burdorff et al.
6,752,816 B2 6/2004 Culp et al.
6,755,195 B1 6/2004 Lemke et al.
6,755,338 B2 6/2004 Hahnen et al.
6,758,846 B2 7/2004 Goble et al.
6,761,685 B2 7/2004 Adams et al.
6,767,352 B2 7/2004 Field et al.
6,767,356 B2 7/2004 Kanner et al.
6,769,590 B2 8/2004 Vresh et al.
6,769,594 B2 8/2004 Orban, III
6,770,072 B1 8/2004 Truckai et al.
6,773,409 B2 8/2004 Truckai et al.
6,773,438 B1 8/2004 Knodel et al.
6,777,838 B2 8/2004 Miekka et al.
6,780,151 B2 8/2004 Grabover et al.
6,780,180 B1 8/2004 Goble et al.
6,783,524 B2 8/2004 Anderson et al.
6,786,382 B1 9/2004 Hoffman
6,786,864 B2 9/2004 Matsuura et al.
6,786,896 B1 9/2004 Madani et al.
6,790,173 B2 9/2004 Saadat et al.
6,793,652 B1 9/2004 Whitman et al.
6,793,661 B2 9/2004 Hamilton et al.
6,793,663 B2 9/2004 Kneifel et al.
6,802,843 B2 10/2004 Truckai et al.
6,805,273 B2 10/2004 Bilotti et al.
6,806,808 B1 10/2004 Watters et al.
6,808,525 B2 10/2004 Latterell et al.
6,814,741 B2 11/2004 Bowman et al.
6,817,508 B1 11/2004 Racenet et al.
6,817,509 B2 11/2004 Geiste et al.
6,817,974 B2 11/2004 Cooper et al.
6,818,018 B1 11/2004 Sawhney
6,820,791 B2 11/2004 Adams
6,821,273 B2 11/2004 Mollenauer
6,821,284 B2 11/2004 Sturtz et al.
6,827,246 B2 12/2004 Sullivan et al.
6,827,712 B2 12/2004 Tovey et al.
6,827,725 B2 12/2004 Batchelor et al.
6,828,902 B2 12/2004 Casden
6,830,174 B2 12/2004 Hillstead et al.
6,831,629 B2 12/2004 Nishino et al.
6,832,998 B2 12/2004 Goble
6,834,001 B2 12/2004 Myono
6,835,199 B2 12/2004 McGuckin, Jr. et al.
6,835,336 B2 12/2004 Watt
6,837,846 B2 1/2005 Jaffe et al.
6,838,493 B2 1/2005 Williams et al.
6,840,423 B2 1/2005 Adams et al.
6,843,403 B2 1/2005 Whitman
6,843,789 B2 1/2005 Goble
6,843,793 B2 1/2005 Brock et al.
6,846,307 B2 1/2005 Whitman et al.
6,846,308 B2 1/2005 Whitman et al.
6,846,309 B2 1/2005 Whitman et al.
6,849,071 B2 2/2005 Whitman et al.
6,858,005 B2 2/2005 Ohline et al.
RE38,708 E 3/2005 Bolanos et al.
6,861,142 B1 * 3/2005 Wilkie et al. 428/373
6,863,694 B1 3/2005 Boyce et al.
6,866,178 B2 3/2005 Adams et al.
6,866,671 B2 3/2005 Tierney et al.
6,867,248 B1 3/2005 Martin et al.
6,869,435 B2 3/2005 Blake, III
6,872,214 B2 3/2005 Sonnenschein et al.
6,874,669 B2 4/2005 Adams et al.
6,877,647 B2 4/2005 Green et al.
6,878,106 B1 4/2005 Herrmann
6,889,116 B2 5/2005 Jinno
6,893,435 B2 5/2005 Goble
6,905,057 B2 6/2005 Swayze et al.
6,905,497 B2 6/2005 Truckai et al.
6,908,472 B2 6/2005 Wiener et al.
6,911,033 B2 6/2005 de Guillebon et al.
6,913,579 B2 7/2005 Truckai et al.
6,913,608 B2 7/2005 Liddicoat et al.
6,913,613 B2 7/2005 Schwarz et al.
6,921,397 B2 7/2005 Corcoran et al.
6,921,412 B1 7/2005 Black et al.
6,923,803 B2 8/2005 Goble
6,926,716 B2 8/2005 Baker et al.
6,929,641 B2 8/2005 Goble et al.
6,929,644 B2 8/2005 Truckai et al.
6,931,830 B2 8/2005 Liao
6,932,218 B2 8/2005 Kosann et al.
6,932,810 B2 8/2005 Ryan
6,936,042 B2 8/2005 Wallace et al.
6,939,358 B2 9/2005 Palacios et al.
6,942,662 B2 9/2005 Goble et al.
6,945,444 B2 9/2005 Gresham et al.
6,953,138 B1 10/2005 Dworak et al.
6,953,139 B2 10/2005 Milliman et al.
6,958,035 B2 10/2005 Friedman et al.
6,959,851 B2 11/2005 Heinrich
6,959,852 B2 11/2005 Shelton, IV et al.
6,960,107 B1 11/2005 Schaub et al.
6,960,163 B2 11/2005 Ewers et al.
6,960,220 B2 11/2005 Marino et al.
6,964,363 B2 11/2005 Wales et al.
6,966,907 B2 11/2005 Goble
6,966,909 B2 11/2005 Marshall et al.
6,971,988 B2 12/2005 Orban, III
6,972,199 B2 12/2005 Lebouitz et al.
6,974,462 B2 12/2005 Sater
6,978,921 B2 12/2005 Shelton, IV et al.
6,978,922 B2 12/2005 Bilotti et al.

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,981,628 B2 1/2006 Wales
6,981,941 B2 1/2006 Whitman et al.
6,981,978 B2 1/2006 Gannoe
6,984,203 B2 1/2006 Tartaglia et al.
6,984,231 B2 1/2006 Goble et al.
6,986,451 B1 1/2006 Mastri et al.
6,988,649 B2 1/2006 Shelton, IV et al.
6,988,650 B2 1/2006 Schwemberger et al.
6,990,796 B2 1/2006 Schnipke et al.
6,994,708 B2 2/2006 Manzo
6,995,729 B2 2/2006 Govari et al.
6,997,931 B2 2/2006 Sauer et al.
7,000,818 B2 2/2006 Shelton, IV et al.
7,000,819 B2 2/2006 Swayze et al.
7,001,380 B2 2/2006 Goble
7,001,408 B2 2/2006 Knodel et al.
7,008,435 B2 3/2006 Cummins
7,009,039 B2 3/2006 Yayon et al.
7,011,657 B2 3/2006 Truckai et al.
7,018,357 B2 3/2006 Emmons
7,018,390 B2 3/2006 Turovskiy et al.
7,025,743 B2 4/2006 Mann et al.
7,029,435 B2 4/2006 Nakao
7,032,798 B2 4/2006 Whitman et al.
7,032,799 B2 4/2006 Viola et al.
7,033,356 B2 4/2006 Latterell et al.
7,036,680 B1 5/2006 Flannery
7,037,344 B2 5/2006 Kagan et al.
7,041,102 B2 5/2006 Truckai et al.
7,041,868 B2 5/2006 Greene et al.
7,043,852 B2 5/2006 Hayashida et al.
7,044,352 B2 5/2006 Shelton, IV et al.
7,044,353 B2 5/2006 Mastri et al.
7,048,687 B1 5/2006 Reuss et al.
7,048,745 B2 5/2006 Tierney et al.
7,052,494 B2 5/2006 Goble et al.
7,055,730 B2 6/2006 Ehrenfels et al.
7,055,731 B2 6/2006 Shelton, IV et al.
7,056,284 B2 6/2006 Martone et al.
7,056,330 B2 6/2006 Gayton
7,059,331 B2 6/2006 Adams et al.
7,059,508 B2 6/2006 Shelton, IV et al.
7,063,712 B2 6/2006 Vargas et al.
7,066,879 B2 6/2006 Fowler et al.
7,066,944 B2 6/2006 Laufer et al.
7,067,038 B2 6/2006 Trokhan et al.
7,070,083 B2 7/2006 Jankowski
7,070,559 B2 7/2006 Adams et al.
7,070,597 B2 7/2006 Truckai et al.
7,071,287 B2 7/2006 Rhine et al.
7,075,770 B1 7/2006 Smith
7,077,856 B2 7/2006 Whitman
7,080,769 B2 7/2006 Vresh et al.
7,081,114 B2 7/2006 Rashidi
7,083,073 B2 8/2006 Yoshie et al.
7,083,075 B2 8/2006 Swayze et al.
7,083,571 B2 8/2006 Wang et al.
7,083,615 B2 8/2006 Peterson et al.
7,083,619 B2 8/2006 Truckai et al.
7,083,620 B2 8/2006 Jahns et al.
7,087,054 B2 8/2006 Truckai et al.
7,087,071 B2 8/2006 Nicholas et al.
7,090,637 B2 8/2006 Danitz et al.
7,090,673 B2 8/2006 Dycus et al.
7,090,683 B2 8/2006 Brock et al.
7,090,684 B2 8/2006 McGuckin, Jr. et al.
7,094,202 B2 8/2006 Nobis et al.
7,094,247 B2 8/2006 Monassevitch et al.
7,097,089 B2 8/2006 Marczyk
7,097,644 B2 8/2006 Long
7,097,650 B2 8/2006 Weller et al.
7,098,794 B2 8/2006 Lindsay et al.
7,104,741 B2 9/2006 Krohn
7,108,695 B2 9/2006 Witt et al.
7,108,701 B2 9/2006 Evens et al.
7,108,709 B2 9/2006 Cummins
7,111,769 B2 9/2006 Wales et al.
7,112,214 B2 9/2006 Peterson et al.
RE39,358 E 10/2006 Goble
7,114,642 B2 10/2006 Whitman
7,118,582 B1 10/2006 Wang et al.
7,121,446 B2 10/2006 Arad et al.
7,122,028 B2 10/2006 Looper et al.
7,125,409 B2 10/2006 Truckai et al.
7,126,303 B2 10/2006 Farritor et al.
7,128,253 B2 10/2006 Mastri et al.
7,128,254 B2 10/2006 Shelton, IV et al.
7,128,748 B2 10/2006 Mooradian et al.
7,131,445 B2 11/2006 Amoah
7,133,601 B2 11/2006 Phillips et al.
7,134,587 B2 11/2006 Schwemberger et al.
7,137,981 B2 11/2006 Long
7,140,527 B2 11/2006 Ehrenfels et al.
7,140,528 B2 11/2006 Shelton, IV
7,143,923 B2 12/2006 Shelton, IV et al.
7,143,924 B2 12/2006 Scirica et al.
7,143,925 B2 12/2006 Shelton, IV et al.
7,143,926 B2 12/2006 Shelton, IV et al.
7,147,138 B2 12/2006 Shelton, IV
7,147,139 B2 12/2006 Schwemberger et al.
7,147,140 B2 12/2006 Wukusick et al.
7,147,637 B2 12/2006 Goble
7,147,650 B2 12/2006 Lee
7,150,748 B2 12/2006 Ebbutt et al.
7,153,300 B2 12/2006 Goble
7,156,863 B2 1/2007 Sonnenschein et al.
7,159,750 B2 1/2007 Racenet et al.
7,160,299 B2 1/2007 Baily
7,161,036 B2 1/2007 Oikawa et al.
7,168,604 B2 1/2007 Milliman et al.
7,172,104 B2 2/2007 Scirica et al.
7,179,223 B2 2/2007 Motoki et al.
7,179,267 B2 2/2007 Nolan et al.
7,182,239 B1 2/2007 Myers
7,182,763 B2 2/2007 Nardella
7,183,737 B2 2/2007 Kitagawa
7,188,758 B2 3/2007 Viola et al.
7,189,207 B2 3/2007 Viola
7,195,627 B2 3/2007 Amoah et al.
7,199,537 B2 4/2007 Okamura et al.
7,204,835 B2 4/2007 Latterell et al.
7,207,233 B2 4/2007 Wadge
7,207,471 B2 4/2007 Heinrich et al.
7,207,472 B2 4/2007 Wukusick et al.
7,207,556 B2 4/2007 Saitoh et al.
7,208,005 B2 4/2007 Frecker et al.
7,210,609 B2 5/2007 Leiboff et al.
7,211,081 B2 5/2007 Goble
7,211,084 B2 5/2007 Goble et al.
7,213,736 B2 5/2007 Wales et al.
7,214,224 B2 5/2007 Goble
7,217,285 B2 5/2007 Vargas et al.
7,220,260 B2 5/2007 Fleming et al.
7,220,272 B2 5/2007 Weadock
7,225,963 B2 6/2007 Scirica
7,225,964 B2 6/2007 Mastri et al.
7,234,624 B2 6/2007 Gresham et al.
7,235,089 B1 6/2007 McGuckin, Jr.
7,235,302 B2 6/2007 Jing et al.
7,237,708 B1 7/2007 Guy et al.
7,238,195 B2 7/2007 Viola
7,241,288 B2 7/2007 Braun
7,246,734 B2 7/2007 Shelton, IV
7,247,161 B2 7/2007 Johnston et al.
7,252,660 B2 8/2007 Kunz
7,255,696 B2 8/2007 Goble et al.
7,256,695 B2 8/2007 Hamel et al.
7,258,262 B2 8/2007 Mastri et al.
7,258,546 B2 8/2007 Beier et al.
7,260,431 B2 8/2007 Libbus et al.
7,265,374 B2 9/2007 Lee et al.
7,267,679 B2 9/2007 McGuckin, Jr. et al.
7,273,483 B2 9/2007 Wiener et al.
7,278,562 B2 10/2007 Mastri et al.

(56) **References Cited**

U.S. PATENT DOCUMENTS

7,278,563	B1	10/2007	Green
7,278,949	B2	10/2007	Bader
7,278,994	B2	10/2007	Goble
7,282,048	B2	10/2007	Goble et al.
7,287,682	B1	10/2007	Ezzat et al.
7,293,685	B2	11/2007	Ehrenfels et al.
7,295,907	B2	11/2007	Lu et al.
7,296,722	B2	11/2007	Ivanko
7,296,724	B2	11/2007	Green et al.
7,297,149	B2	11/2007	Vitali et al.
7,300,450	B2	11/2007	Vleugels et al.
7,303,106	B2	12/2007	Milliman et al.
7,303,107	B2	12/2007	Milliman et al.
7,303,108	B2	12/2007	Shelton, IV
7,303,502	B2	12/2007	Thompson
7,303,556	B2	12/2007	Metzger
7,308,998	B2	12/2007	Mastri et al.
7,322,975	B2	1/2008	Goble et al.
7,322,994	B2	1/2008	Nicholas et al.
7,324,572	B2	1/2008	Chang
7,326,203	B2	2/2008	Papineau et al.
7,326,213	B2	2/2008	Benderev et al.
7,328,828	B2	2/2008	Ortiz et al.
7,328,829	B2	2/2008	Arad et al.
7,330,004	B2	2/2008	DeJonge et al.
7,331,340	B2	2/2008	Barney
7,334,717	B2	2/2008	Rethy et al.
7,334,718	B2	2/2008	McAlister et al.
7,335,199	B2	2/2008	Goble et al.
7,336,048	B2	2/2008	Lohr
7,336,184	B2	2/2008	Smith et al.
7,338,513	B2	3/2008	Lee et al.
7,341,591	B2	3/2008	Grinberg
7,343,920	B2	3/2008	Toby et al.
7,344,532	B2	3/2008	Goble et al.
7,348,763	B1	3/2008	Reinhart et al.
RE40,237	E	4/2008	Bilotti et al.
7,351,258	B2	4/2008	Ricotta et al.
7,354,447	B2	4/2008	Shelton, IV et al.
7,354,502	B2	4/2008	Polat et al.
7,357,287	B2	4/2008	Shelton, IV et al.
7,357,806	B2	4/2008	Rivera et al.
7,361,195	B2	4/2008	Schwartz et al.
7,364,060	B2	4/2008	Milliman
7,364,061	B2	4/2008	Swayze et al.
7,377,918	B2	5/2008	Amoah
7,377,928	B2	5/2008	Zubik et al.
7,380,695	B2	6/2008	Doll et al.
7,380,696	B2	6/2008	Shelton, IV et al.
7,386,730	B2	6/2008	Uchikubo
7,388,217	B2	6/2008	Buschbeck et al.
7,391,173	B2	6/2008	Schena
7,396,356	B2	7/2008	Mollenauer
7,397,364	B2	7/2008	Govari
7,398,907	B2	7/2008	Racenet et al.
7,398,908	B2	7/2008	Holsten et al.
7,401,721	B2	7/2008	Holsten et al.
7,404,508	B2	7/2008	Smith et al.
7,404,509	B2	7/2008	Ortiz et al.
7,404,822	B2	7/2008	Viart et al.
7,407,074	B2	8/2008	Ortiz et al.
7,407,075	B2	8/2008	Holsten et al.
7,407,076	B2	8/2008	Racenet et al.
7,407,077	B2	8/2008	Ortiz et al.
7,407,078	B2	8/2008	Shelton, IV et al.
7,410,086	B2	8/2008	Ortiz et al.
7,413,563	B2	8/2008	Corcoran et al.
7,416,101	B2	8/2008	Shelton, IV et al.
7,418,078	B2	8/2008	Blanz et al.
RE40,514	E	9/2008	Mastri et al.
7,419,080	B2	9/2008	Smith et al.
7,419,081	B2	9/2008	Ehrenfels et al.
7,419,495	B2	9/2008	Menn et al.
7,422,136	B1	9/2008	Marczyk
7,422,139	B2	9/2008	Shelton, IV et al.
7,424,965	B2	9/2008	Racenet et al.
7,427,607	B2	9/2008	Suzuki
7,431,188	B1	10/2008	Marczyk
7,431,189	B2	10/2008	Shelton, IV et al.
7,431,694	B2	10/2008	Stefanchik et al.
7,431,730	B2	10/2008	Viola
7,434,715	B2	10/2008	Shelton, IV et al.
7,434,717	B2	10/2008	Shelton, IV et al.
7,438,209	B1	10/2008	Hess et al.
7,438,718	B2	10/2008	Milliman et al.
7,439,354	B2	10/2008	Lenges et al.
7,441,684	B2	10/2008	Shelton, IV et al.
7,441,685	B1	10/2008	Boudreaux
7,442,201	B2	10/2008	Pugsley et al.
7,448,525	B2	11/2008	Shelton, IV et al.
7,451,904	B2	11/2008	Shelton, IV
7,455,208	B2	11/2008	Wales et al.
7,455,676	B2	11/2008	Holsten et al.
7,455,682	B2	11/2008	Viola
7,461,767	B2	12/2008	Viola et al.
7,462,187	B2	12/2008	Johnston et al.
7,464,846	B2	12/2008	Shelton, IV et al.
7,464,847	B2	12/2008	Viola et al.
7,464,849	B2	12/2008	Shelton, IV et al.
7,467,740	B2	12/2008	Shelton, IV et al.
7,467,849	B2	12/2008	Silverbrook et al.
7,472,814	B2	1/2009	Mastri et al.
7,472,815	B2	1/2009	Shelton, IV et al.
7,472,816	B2	1/2009	Holsten et al.
7,473,253	B2	1/2009	Dycus et al.
7,473,263	B2	1/2009	Johnston et al.
7,479,608	B2	1/2009	Smith
7,481,347	B2	1/2009	Roy
7,481,348	B2	1/2009	Marczyk
7,481,349	B2	1/2009	Holsten et al.
7,481,824	B2	1/2009	Boudreaux et al.
7,485,133	B2	2/2009	Cannon et al.
7,485,142	B2	2/2009	Milo
7,487,899	B2	2/2009	Shelton, IV et al.
7,490,749	B2	2/2009	Schall et al.
7,494,039	B2	2/2009	Racenet et al.
7,494,499	B2	2/2009	Nagase et al.
7,500,979	B2	3/2009	Hueil et al.
7,501,198	B2	3/2009	Barlev et al.
7,503,474	B2	3/2009	Hillstead et al.
7,506,790	B2	3/2009	Shelton, IV
7,506,791	B2	3/2009	Omaits et al.
7,507,202	B2	3/2009	Schoellhorn
7,510,107	B2	3/2009	Timm et al.
7,510,566	B2	3/2009	Jacobs et al.
7,513,408	B2	4/2009	Shelton, IV et al.
7,517,356	B2	4/2009	Heinrich
7,524,320	B2	4/2009	Tierney et al.
7,530,984	B2	5/2009	Sonnenschein et al.
7,530,985	B2	5/2009	Takemoto et al.
7,546,939	B2	6/2009	Adams et al.
7,546,940	B2	6/2009	Milliman et al.
7,547,312	B2	6/2009	Bauman et al.
7,549,563	B2	6/2009	Mather et al.
7,549,564	B2	6/2009	Boudreaux
7,549,998	B2	6/2009	Braun
7,552,854	B2	6/2009	Wixey et al.
7,556,185	B2	7/2009	Viola
7,556,186	B2	7/2009	Milliman
7,556,647	B2	7/2009	Drews et al.
7,559,449	B2	7/2009	Viola
7,559,450	B2	7/2009	Wales et al.
7,559,452	B2	7/2009	Wales et al.
7,563,862	B2	7/2009	Sieg et al.
7,565,993	B2	7/2009	Milliman et al.
7,566,300	B2	7/2009	Devierre et al.
7,567,045	B2	7/2009	Fristedt
7,568,603	B2	8/2009	Shelton, IV et al.
7,568,604	B2	8/2009	Ehrenfels et al.
7,568,619	B2	8/2009	Todd et al.
7,575,144	B2	8/2009	Ortiz et al.
7,588,174	B2	9/2009	Holsten et al.
7,588,175	B2	9/2009	Timm et al.
7,588,176	B2	9/2009	Timm et al.

(56) **References Cited**

U.S. PATENT DOCUMENTS

7,588,177	B2	9/2009	Racenet
7,591,783	B2	9/2009	Boulais et al.
7,597,229	B2	10/2009	Boudreaux et al.
7,597,230	B2	10/2009	Racenet et al.
7,600,663	B2	10/2009	Green
7,604,150	B2	10/2009	Boudreaux
7,604,151	B2	10/2009	Hess et al.
7,607,557	B2	10/2009	Shelton, IV et al.
7,611,038	B2	11/2009	Racenet et al.
7,611,474	B2	11/2009	Hibner et al.
7,615,003	B2	11/2009	Stefanchik et al.
7,615,067	B2	11/2009	Lee et al.
7,624,902	B2	12/2009	Marczyk et al.
7,624,903	B2	12/2009	Green et al.
7,625,370	B2	12/2009	Hart et al.
7,631,793	B2	12/2009	Rethy et al.
7,631,794	B2	12/2009	Rethy et al.
7,635,074	B2	12/2009	Olson et al.
7,637,409	B2	12/2009	Marczyk
7,638,958	B2	12/2009	Philipp et al.
7,641,091	B2	1/2010	Olson et al.
7,641,092	B2	1/2010	Kruszynski et al.
7,641,093	B2	1/2010	Doll et al.
7,641,095	B2	1/2010	Viola
7,644,783	B2	1/2010	Roberts et al.
7,644,848	B2	1/2010	Swayze et al.
7,645,230	B2	1/2010	Mikkaichi et al.
7,648,519	B2	1/2010	Lee et al.
7,651,017	B2	1/2010	Ortiz et al.
7,651,498	B2	1/2010	Shifrin et al.
7,654,431	B2	2/2010	Hueil et al.
7,656,131	B2	2/2010	Embrey et al.
7,658,311	B2	2/2010	Boudreaux
7,658,312	B2	2/2010	Vidal et al.
7,659,219	B2	2/2010	Biran et al.
7,662,161	B2	2/2010	Briganti et al.
7,665,646	B2	2/2010	Prommersberger
7,665,647	B2	2/2010	Shelton, IV et al.
7,669,746	B2	3/2010	Shelton, IV
7,669,747	B2	3/2010	Weisenburgh, II et al.
7,670,334	B2	3/2010	Hueil et al.
7,673,780	B2	3/2010	Shelton, IV et al.
7,673,781	B2	3/2010	Swayze et al.
7,673,782	B2	3/2010	Hess et al.
7,673,783	B2	3/2010	Morgan et al.
7,674,253	B2	3/2010	Fisher et al.
7,674,255	B2	3/2010	Braun
7,674,263	B2	3/2010	Ryan
7,682,307	B2	3/2010	Danitz et al.
7,686,201	B2	3/2010	Csiky
7,686,826	B2	3/2010	Lee et al.
7,688,028	B2	3/2010	Phillips et al.
7,691,098	B2	4/2010	Wallace et al.
7,691,106	B2	4/2010	Schenberger et al.
7,694,865	B2	4/2010	Scirica
7,695,485	B2	4/2010	Whitman et al.
7,699,204	B2	4/2010	Viola
7,699,835	B2	4/2010	Lee et al.
7,699,844	B2	4/2010	Utley et al.
7,699,846	B2	4/2010	Ryan
7,699,856	B2	4/2010	Van Wyk et al.
7,699,859	B2	4/2010	Bombard et al.
7,699,860	B2	4/2010	Huitema et al.
7,703,653	B2	4/2010	Shah et al.
7,708,180	B2	5/2010	Murray et al.
7,708,181	B2	5/2010	Cole et al.
7,708,758	B2	5/2010	Lee et al.
7,714,239	B2	5/2010	Smith
7,717,312	B2	5/2010	Beetel
7,717,313	B2	5/2010	Criscuolo et al.
7,717,846	B2	5/2010	Zirps et al.
7,718,180	B2	5/2010	Karp
7,718,556	B2	5/2010	Matsuda et al.
7,721,930	B2	5/2010	McKenna et al.
7,721,931	B2	5/2010	Shelton, IV et al.
7,721,933	B2	5/2010	Ehrenfels et al.
7,721,934	B2	5/2010	Shelton, IV et al.
7,721,936	B2	5/2010	Shelton, IV et al.
7,722,527	B2	5/2010	Bouchier et al.
7,722,607	B2	5/2010	Dumbauld et al.
7,722,610	B2	5/2010	Viola et al.
7,726,537	B2	6/2010	Olson et al.
7,726,538	B2	6/2010	Holsten et al.
7,726,539	B2	6/2010	Holsten et al.
7,731,072	B2	6/2010	Timm et al.
7,731,073	B2	6/2010	Wixey et al.
7,731,724	B2	6/2010	Huitema et al.
7,735,703	B2	6/2010	Morgan et al.
7,736,374	B2	6/2010	Vaughan et al.
7,738,971	B2	6/2010	Swayze et al.
7,740,159	B2	6/2010	Shelton, IV et al.
7,743,960	B2	6/2010	Whitman et al.
7,744,624	B2	6/2010	Bettuchi
7,744,627	B2	6/2010	Orban, III et al.
7,744,628	B2	6/2010	Viola
7,748,587	B2	7/2010	Haramiishi et al.
7,749,204	B2	7/2010	Dhanaraj et al.
7,751,870	B2	7/2010	Whitman
7,753,245	B2	7/2010	Boudreaux et al.
7,753,904	B2	7/2010	Shelton, IV et al.
7,758,612	B2	7/2010	Shipp
7,766,209	B2	8/2010	Baxter, III et al.
7,766,210	B2	8/2010	Shelton, IV et al.
7,766,821	B2	8/2010	Brunnen et al.
7,766,894	B2	8/2010	Weitzner et al.
7,770,773	B2	8/2010	Whitman et al.
7,770,774	B2	8/2010	Mastri et al.
7,770,775	B2	8/2010	Shelton, IV et al.
7,770,776	B2	8/2010	Chen et al.
7,771,396	B2	8/2010	Stefanchik et al.
7,772,720	B2	8/2010	McGee et al.
7,776,060	B2	8/2010	Mooradian et al.
7,778,004	B2	8/2010	Nerheim et al.
7,780,054	B2	8/2010	Wales
7,780,055	B2	8/2010	Scirica et al.
7,780,663	B2	8/2010	Yates et al.
7,780,685	B2	8/2010	Hunt et al.
7,784,662	B2	8/2010	Wales et al.
7,784,663	B2	8/2010	Shelton, IV
7,789,875	B2	9/2010	Brock et al.
7,789,883	B2	9/2010	Takashino et al.
7,789,889	B2	9/2010	Zubik et al.
7,793,812	B2	9/2010	Moore et al.
7,794,475	B2	9/2010	Hess et al.
7,798,386	B2	9/2010	Schall et al.
7,799,039	B2	9/2010	Shelton, IV et al.
7,799,044	B2	9/2010	Johnston et al.
7,803,151	B2	9/2010	Whitman
7,806,891	B2	10/2010	Nowlin et al.
7,810,690	B2	10/2010	Bilotti et al.
7,810,691	B2	10/2010	Boyden et al.
7,810,692	B2	10/2010	Hall et al.
7,810,693	B2	10/2010	Broehl et al.
7,815,092	B2	10/2010	Whitman et al.
7,815,565	B2	10/2010	Stefanchik et al.
7,819,296	B2	10/2010	Hueil et al.
7,819,297	B2	10/2010	Doll et al.
7,819,298	B2	10/2010	Hall et al.
7,819,299	B2	10/2010	Shelton, IV et al.
7,819,886	B2	10/2010	Whitfield et al.
7,823,592	B2	11/2010	Bettuchi et al.
7,824,401	B2	11/2010	Manzo et al.
7,824,426	B2	11/2010	Racenet et al.
7,828,189	B2	11/2010	Holsten et al.
7,828,794	B2	11/2010	Sartor
7,828,808	B2	11/2010	Hinman et al.
7,832,408	B2	11/2010	Shelton, IV et al.
7,832,611	B2	11/2010	Boyden et al.
7,832,612	B2	11/2010	Baxter, III et al.
7,833,234	B2	11/2010	Bailly et al.
7,836,400	B2	11/2010	May et al.
7,837,079	B2	11/2010	Holsten et al.
7,837,080	B2	11/2010	Schwemberger
7,837,081	B2	11/2010	Holsten et al.

(56) **References Cited**

U.S. PATENT DOCUMENTS

7,837,694	B2	11/2010	Tethrake et al.
7,841,503	B2	11/2010	Sonnenschein et al.
7,842,025	B2	11/2010	Coleman et al.
7,842,028	B2	11/2010	Lee
7,845,533	B2	12/2010	Marczyk et al.
7,845,534	B2	12/2010	Viola et al.
7,845,535	B2	12/2010	Scircia
7,845,536	B2	12/2010	Viola et al.
7,845,537	B2	12/2010	Shelton, IV et al.
7,846,149	B2	12/2010	Jankowski
7,850,642	B2	12/2010	Moll et al.
7,850,982	B2	12/2010	Stopek et al.
7,854,736	B2	12/2010	Ryan
7,857,183	B2	12/2010	Shelton, IV
7,857,185	B2	12/2010	Swayze et al.
7,857,186	B2	12/2010	Baxter, III et al.
7,857,813	B2	12/2010	Schmitz et al.
7,861,906	B2	1/2011	Doll et al.
7,862,579	B2	1/2011	Ortiz et al.
7,866,525	B2	1/2011	Scirica
7,866,527	B2	1/2011	Hall et al.
7,866,528	B2	1/2011	Olson et al.
7,870,989	B2	1/2011	Viola et al.
7,871,418	B2	1/2011	Thompson et al.
7,879,070	B2	2/2011	Ortiz et al.
7,883,465	B2	2/2011	Donofrio et al.
7,886,951	B2	2/2011	Hessler
7,886,952	B2	2/2011	Scirica et al.
7,887,530	B2	2/2011	Zemlok et al.
7,887,535	B2	2/2011	Lands et al.
7,891,531	B1	2/2011	Ward
7,891,532	B2	2/2011	Mastri et al.
7,893,586	B2	2/2011	West et al.
7,896,214	B2	3/2011	Farascioni
7,896,215	B2	3/2011	Adams et al.
7,896,877	B2	3/2011	Hall et al.
7,900,805	B2	3/2011	Shelton, IV et al.
7,905,380	B2	3/2011	Shelton, IV et al.
7,905,381	B2	3/2011	Baxter, III et al.
7,905,889	B2	3/2011	Catanese, III et al.
7,905,902	B2	3/2011	Huitema et al.
7,909,191	B2	3/2011	Baker et al.
7,909,220	B2	3/2011	Viola
7,909,221	B2	3/2011	Viola et al.
7,913,891	B2	3/2011	Doll et al.
7,913,893	B2	3/2011	Mastri et al.
7,914,543	B2	3/2011	Roth et al.
7,914,551	B2	3/2011	Ortiz et al.
7,918,376	B1	4/2011	Knodel et al.
7,918,377	B2	4/2011	Measamer et al.
7,918,848	B2	4/2011	Lau et al.
7,922,061	B2	4/2011	Shelton, IV et al.
7,922,063	B2	4/2011	Zemlok et al.
7,922,743	B2	4/2011	Heinrich et al.
7,926,691	B2	4/2011	Viola et al.
7,927,328	B2	4/2011	Orszulak et al.
7,931,660	B2	4/2011	Aranyi et al.
7,931,695	B2	4/2011	Ringeisen
7,934,630	B2	5/2011	Shelton, IV et al.
7,934,631	B2	5/2011	Balbierz et al.
7,935,773	B2	5/2011	Hadba et al.
7,938,307	B2	5/2011	Bettuchi
7,941,865	B2	5/2011	Seman, Jr. et al.
7,942,303	B2	5/2011	Shah
7,942,890	B2	5/2011	D'Agostino et al.
7,944,175	B2	5/2011	Mori et al.
7,950,560	B2	5/2011	Zemlok et al.
7,950,561	B2	5/2011	Aranyi
7,951,071	B2	5/2011	Whitman et al.
7,951,166	B2	5/2011	Orban et al.
7,954,682	B2	6/2011	Giordano et al.
7,954,684	B2	6/2011	Boudreaux
7,954,686	B2	6/2011	Baxter, III et al.
7,954,687	B2	6/2011	Zemlok et al.
7,955,257	B2	6/2011	Frasier et al.
7,959,050	B2	6/2011	Smith et al.
7,959,051	B2	6/2011	Smith et al.
7,959,052	B2	6/2011	Sonnenschein et al.
7,963,432	B2	6/2011	Knodel et al.
7,963,433	B2	6/2011	Whitman et al.
7,963,963	B2	6/2011	Francischelli et al.
7,963,964	B2	6/2011	Santilli et al.
7,966,799	B2	6/2011	Morgan et al.
7,967,180	B2	6/2011	Scirica
7,967,181	B2	6/2011	Viola et al.
7,967,839	B2	6/2011	Flock et al.
7,972,298	B2	7/2011	Wallace et al.
7,980,443	B2	7/2011	Scheib et al.
7,988,026	B2	8/2011	Knodel et al.
7,988,027	B2	8/2011	Olson et al.
7,988,028	B2	8/2011	Farascioni et al.
7,992,757	B2	8/2011	Wheeler et al.
7,997,469	B2	8/2011	Olson et al.
8,002,696	B2	8/2011	Suzuki
8,002,784	B2	8/2011	Jinno et al.
8,002,785	B2	8/2011	Weiss et al.
8,002,795	B2	8/2011	Beetel
8,006,365	B2	8/2011	Levin et al.
8,006,885	B2	8/2011	Marczyk
8,006,889	B2	8/2011	Adams et al.
8,011,550	B2	9/2011	Aranyi et al.
8,011,551	B2	9/2011	Marczyk et al.
8,011,553	B2	9/2011	Mastri et al.
8,011,555	B2	9/2011	Tarinelli et al.
8,016,176	B2	9/2011	Kasvikis et al.
8,016,177	B2	9/2011	Bettuchi et al.
8,016,178	B2	9/2011	Olson et al.
8,016,855	B2	9/2011	Whitman et al.
8,016,858	B2	9/2011	Whitman
8,016,881	B2	9/2011	Furst
8,020,742	B2	9/2011	Marczyk
8,020,743	B2	9/2011	Shelton, IV
8,021,375	B2	9/2011	Aldrich et al.
8,025,199	B2	9/2011	Whitman et al.
8,028,883	B2	10/2011	Stopek
8,028,884	B2	10/2011	Sniffin et al.
8,028,885	B2	10/2011	Smith et al.
8,034,077	B2	10/2011	Smith et al.
8,034,363	B2	10/2011	Li et al.
8,037,591	B2	10/2011	Spivey et al.
8,038,045	B2	10/2011	Bettuchi et al.
8,038,046	B2	10/2011	Smith et al.
8,038,686	B2	10/2011	Huitema et al.
8,043,207	B2	10/2011	Adams
8,043,328	B2	10/2011	Hahnen et al.
8,047,236	B2	11/2011	Perry
8,056,787	B2	11/2011	Boudreaux et al.
8,056,788	B2	11/2011	Mastri et al.
8,057,508	B2	11/2011	Shelton, IV
8,061,576	B2	11/2011	Cappola
8,062,330	B2	11/2011	Prommersberger et al.
8,066,167	B2	11/2011	Measamer et al.
8,066,168	B2	11/2011	Vidal et al.
D650,074	S	12/2011	Hunt et al.
8,070,743	B2	12/2011	Kagan et al.
8,075,571	B2	12/2011	Vitali et al.
8,083,118	B2	12/2011	Milliman et al.
8,083,119	B2	12/2011	Prommersberger
8,083,120	B2	12/2011	Shelton, IV et al.
8,084,001	B2	12/2011	Burns et al.
8,091,756	B2	1/2012	Viola
8,092,932	B2	1/2012	Phillips et al.
8,096,458	B2	1/2012	Hessler
8,097,017	B2	1/2012	Viola
8,100,310	B2	1/2012	Zemlok
8,105,350	B2	1/2012	Lee et al.
8,108,072	B2	1/2012	Zhao et al.
8,109,426	B2	2/2012	Milliman et al.
8,113,405	B2	2/2012	Milliman
8,113,410	B2	2/2012	Hall et al.
8,114,100	B2	2/2012	Smith et al.
8,123,103	B2	2/2012	Milliman
8,123,766	B2	2/2012	Bauman et al.
8,123,767	B2	2/2012	Bauman et al.

(56) **References Cited**

U.S. PATENT DOCUMENTS

8,127,975 B2 3/2012 Olson et al.
8,128,624 B2 3/2012 Couture et al.
8,128,645 B2 3/2012 Sonnenschein et al.
8,132,703 B2 3/2012 Milliman et al.
8,132,706 B2 3/2012 Marczyk et al.
8,136,712 B2 3/2012 Zingman
8,136,713 B2 3/2012 Hathaway et al.
8,140,417 B2 3/2012 Shibata
8,141,762 B2 3/2012 Bedi et al.
8,141,763 B2 3/2012 Milliman
8,146,790 B2 4/2012 Milliman
8,152,041 B2 4/2012 Kostrzewski
8,157,145 B2 4/2012 Shelton, IV et al.
8,157,148 B2 4/2012 Scirica
8,157,151 B2 4/2012 Ingmanson et al.
8,157,152 B2 4/2012 Holsten et al.
8,157,153 B2 4/2012 Shelton, IV et al.
8,157,793 B2 4/2012 Omori et al.
8,161,977 B2 4/2012 Shelton, IV et al.
8,162,138 B2 4/2012 Bettenhausen et al.
8,162,197 B2 4/2012 Mastri et al.
8,167,185 B2 5/2012 Shelton, IV et al.
8,167,895 B2 5/2012 D'Agostino et al.
8,167,898 B1 5/2012 Schaller et al.
8,172,120 B2 5/2012 Boyden et al.
8,172,122 B2 5/2012 Kasvikis et al.
8,172,124 B2 5/2012 Shelton, IV et al.
8,177,797 B2 5/2012 Shimoji et al.
8,180,458 B2 5/2012 Kane et al.
8,181,840 B2 5/2012 Milliman
8,186,555 B2 5/2012 Shelton, IV et al.
8,186,560 B2 5/2012 Hess et al.
8,191,752 B2 6/2012 Scirica
8,192,460 B2 6/2012 Orban, III et al.
8,196,795 B2 6/2012 Moore et al.
8,196,796 B2 6/2012 Shelton, IV et al.
8,201,720 B2 6/2012 Hessler
8,201,721 B2 6/2012 Zemlok et al.
8,205,780 B2 6/2012 Sorrentino et al.
8,205,781 B2 6/2012 Baxter, III et al.
8,210,411 B2 7/2012 Yates et al.
8,210,414 B2 7/2012 Bettuchi et al.
8,210,415 B2 7/2012 Ward
8,210,416 B2 7/2012 Milliman et al.
8,211,125 B2 7/2012 Spivey
8,214,019 B2 7/2012 Govari et al.
8,215,531 B2 7/2012 Shelton, IV et al.
8,215,533 B2 7/2012 Viola et al.
8,220,468 B2 7/2012 Cooper et al.
8,220,688 B2 7/2012 Laurent et al.
8,220,690 B2 7/2012 Hess et al.
8,221,424 B2 7/2012 Cha
8,225,799 B2 7/2012 Bettuchi
8,231,040 B2 7/2012 Zemlok et al.
8,231,041 B2 7/2012 Marczyk et al.
8,231,042 B2 7/2012 Hessler et al.
8,231,043 B2 7/2012 Tarinelli et al.
8,236,010 B2 8/2012 Ortiz et al.
8,241,271 B2 8/2012 Millman et al.
8,241,308 B2 8/2012 Kortenbach et al.
8,241,322 B2 8/2012 Whitman et al.
8,245,898 B2 8/2012 Smith et al.
8,245,899 B2 8/2012 Swensgard et al.
8,245,900 B2 8/2012 Scirica
8,245,901 B2 8/2012 Stopek
8,246,637 B2 8/2012 Viola et al.
8,256,654 B2 9/2012 Bettuchi et al.
8,256,655 B2 9/2012 Sniffin et al.
8,257,251 B2 9/2012 Shelton, IV et al.
8,257,356 B2 9/2012 Bleich et al.
8,257,391 B2 9/2012 Orban, III et al.
8,267,300 B2 9/2012 Boudreaux
8,267,924 B2 9/2012 Zemlok et al.
8,267,946 B2 9/2012 Whitfield et al.
8,267,951 B2 9/2012 Whayne et al.
8,269,121 B2 9/2012 Smith
8,272,553 B2 9/2012 Mastri et al.
8,272,554 B2 9/2012 Whitman et al.
8,276,801 B2 10/2012 Zemlok et al.
8,276,802 B2 10/2012 Kostrzewski
8,281,973 B2 10/2012 Wenchell et al.
8,286,845 B2 10/2012 Perry et al.
8,287,561 B2 10/2012 Nunez et al.
8,292,151 B2 10/2012 Viola
8,292,155 B2 10/2012 Shelton, IV et al.
8,292,157 B2 10/2012 Smith et al.
8,292,888 B2 10/2012 Whitman
8,298,677 B2 10/2012 Wiesner et al.
8,302,323 B2 11/2012 Fortier et al.
8,308,040 B2 11/2012 Huang et al.
8,308,042 B2 11/2012 Aranyi
8,308,046 B2 11/2012 Prommersberger
8,308,659 B2 11/2012 Scheibe et al.
8,313,496 B2 11/2012 Sauer et al.
8,313,509 B2 11/2012 Kostrzewski
8,317,070 B2 11/2012 Hueil et al.
8,317,071 B1 11/2012 Knodel
8,317,074 B2 11/2012 Ortiz et al.
8,319,002 B2 11/2012 Daniels et al.
8,322,455 B2 12/2012 Shelton, IV et al.
8,322,589 B2 12/2012 Boudreaux
8,323,789 B2 12/2012 Rozhin et al.
8,328,062 B2 12/2012 Viola
8,328,063 B2 12/2012 Milliman et al.
8,328,064 B2 12/2012 Racenet et al.
8,328,802 B2 12/2012 Deville et al.
8,328,823 B2 12/2012 Aranyi et al.
8,333,313 B2 12/2012 Boudreaux et al.
8,333,764 B2 12/2012 Francischelli et al.
8,336,753 B2 12/2012 Olson et al.
8,348,123 B2 1/2013 Scirica et al.
8,348,127 B2 1/2013 Marczyk
8,348,129 B2 1/2013 Bedi et al.
8,348,131 B2 1/2013 Omaits et al.
8,348,972 B2 1/2013 Soltz et al.
8,353,437 B2 1/2013 Boudreaux
8,353,438 B2 1/2013 Baxter, III et al.
8,353,439 B2 1/2013 Baxter, III et al.
8,357,144 B2 1/2013 Whitman et al.
8,360,296 B2 1/2013 Zingman
8,360,297 B2 1/2013 Shelton, IV et al.
8,360,298 B2 1/2013 Farascioni et al.
8,360,299 B2 1/2013 Zemlok et al.
8,365,973 B1 2/2013 White et al.
8,365,976 B2 2/2013 Hess et al.
8,366,559 B2 2/2013 Papenfuss et al.
8,371,491 B2 2/2013 Huitema et al.
8,371,492 B2 2/2013 Aranyi et al.
8,371,493 B2 2/2013 Aranyi et al.
8,372,094 B2 2/2013 Bettuchi et al.
8,376,865 B2 2/2013 Forster et al.
8,377,044 B2 2/2013 Coe et al.
8,393,513 B2 3/2013 Jankowski
8,393,514 B2 3/2013 Shelton, IV et al.
8,397,971 B2 3/2013 Yates et al.
8,398,673 B2 3/2013 Hinchliffe et al.
8,403,138 B2 3/2013 Weisshaupt et al.
8,403,198 B2 3/2013 Sorrentino et al.
8,403,945 B2 3/2013 Whitfield et al.
8,408,439 B2 4/2013 Huang et al.
8,408,442 B2 4/2013 Racenet et al.
8,409,079 B2 4/2013 Oakamoto et al.
8,409,174 B2 4/2013 Omori
8,409,222 B2 4/2013 Whitfield et al.
8,413,870 B2 4/2013 Pastorelli et al.
8,413,871 B2 4/2013 Racenet et al.
8,413,872 B2 4/2013 Patel
8,414,577 B2 4/2013 Boudreaux et al.
8,424,737 B2 4/2013 Scirica
8,424,739 B2 4/2013 Racenet et al.
8,424,740 B2 4/2013 Shelton, IV et al.
8,424,741 B2 4/2013 McGuckin, Jr. et al.
8,430,292 B2 4/2013 Patel et al.
8,430,898 B2 4/2013 Wiener et al.

(56) **References Cited**

U.S. PATENT DOCUMENTS

8,439,246 B1	5/2013	Knodel et al.	
8,444,036 B2	5/2013	Shelton, IV	
8,444,549 B2	5/2013	Viola et al.	
8,453,904 B2	6/2013	Eskaros et al.	
8,453,907 B2	6/2013	Laurent et al.	
8,453,908 B2	6/2013	Bedi et al.	
8,453,912 B2	6/2013	Mastri et al.	
8,453,914 B2	6/2013	Laurent et al.	
8,459,520 B2	6/2013	Giordano et al.	
8,459,525 B2	6/2013	Yates et al.	
8,464,922 B2	6/2013	Marczyk	
8,464,923 B2	6/2013	Shelton, IV	
8,464,924 B2	6/2013	Gresham et al.	
8,464,925 B2	6/2013	Hull et al.	
8,474,677 B2	7/2013	Woodard, Jr. et al.	
8,475,453 B2	7/2013	Marczyk et al.	
8,475,474 B2	7/2013	Bombard et al.	
8,479,969 B2	7/2013	Shelton, IV	
8,485,412 B2	7/2013	Shelton, IV et al.	
8,485,413 B2	7/2013	Scheib et al.	
8,490,853 B2	7/2013	Criscuolo et al.	
8,496,156 B2	7/2013	Sniffin et al.	
8,496,683 B2	7/2013	Prommersberger et al.	
8,499,993 B2	8/2013	Shelton, IV et al.	
8,500,762 B2	8/2013	Sholev et al.	
8,506,557 B2	8/2013	Zemlok et al.	
8,517,239 B2	8/2013	Scheib et al.	
8,517,241 B2	8/2013	Nicholas et al.	
8,517,243 B2	8/2013	Giordano et al.	
8,517,244 B2	8/2013	Shelton, IV et al.	
8,523,881 B2	9/2013	Cabiri et al.	
8,529,588 B2	9/2013	Ahlberg et al.	
8,529,600 B2	9/2013	Woodard, Jr. et al.	
8,534,528 B2	9/2013	Shelton, IV	
8,535,304 B2	9/2013	Sklar et al.	
8,540,128 B2	9/2013	Shelton, IV et al.	
8,540,129 B2	9/2013	Baxter, III et al.	
8,540,130 B2	9/2013	Moore et al.	
8,540,131 B2	9/2013	Swayze	
8,540,133 B2	9/2013	Bedi et al.	
8,540,733 B2	9/2013	Whitman et al.	
8,556,151 B2	10/2013	Viola	
8,556,918 B2	10/2013	Bauman et al.	
8,561,870 B2	10/2013	Baxter, III et al.	
8,561,873 B2	10/2013	Ingmanson et al.	
8,567,656 B2	10/2013	Shelton, IV et al.	
8,573,461 B2	11/2013	Shelton, IV et al.	
8,573,465 B2	11/2013	Shelton, IV et al.	
8,579,176 B2	11/2013	Smith et al.	
8,579,937 B2	11/2013	Gresham	
8,584,919 B2	11/2013	Hueil et al.	
8,585,721 B2	11/2013	Kirsch	
8,590,762 B2	11/2013	Hess et al.	
8,602,287 B2	12/2013	Yates et al.	
8,602,288 B2	12/2013	Shelton, IV et al.	
8,603,135 B2	12/2013	Mueller	
8,608,044 B2	12/2013	Hueil et al.	
8,608,045 B2	12/2013	Smith et al.	
8,608,046 B2	12/2013	Laurent et al.	
8,608,745 B2	12/2013	Guzman et al.	
8,616,431 B2	12/2013	Timm et al.	
8,622,274 B2	1/2014	Yates et al.	
8,622,275 B2	1/2014	Baxter, III et al.	
8,631,987 B2	1/2014	Shelton, IV et al.	
8,632,462 B2	1/2014	Yoo et al.	
8,632,525 B2	1/2014	Kerr et al.	
8,632,535 B2	1/2014	Shelton, IV et al.	
8,632,563 B2	1/2014	Nagase et al.	
8,636,187 B2	1/2014	Hueil et al.	
8,636,736 B2	1/2014	Yates et al.	
8,647,258 B2	2/2014	Aranyi et al.	
8,652,120 B2	2/2014	Giordano et al.	
8,652,151 B2	2/2014	Lehman et al.	
8,657,174 B2	2/2014	Yates et al.	
8,657,178 B2	2/2014	Hueil et al.	
8,663,192 B2	3/2014	Hester et al.	
8,668,129 B2	3/2014	Olson	
8,668,130 B2	3/2014	Hess et al.	
8,672,206 B2	3/2014	Aranyi et al.	
8,672,207 B2	3/2014	Shelton, IV et al.	
8,672,208 B2	3/2014	Hess et al.	
8,678,263 B2	3/2014	Viola	
8,679,137 B2	3/2014	Bauman et al.	
8,679,454 B2	3/2014	Guire et al.	
8,684,253 B2	4/2014	Giordano et al.	
8,685,020 B2	4/2014	Weizman et al.	
8,695,866 B2	4/2014	Leimbach et al.	
8,696,665 B2	4/2014	Hunt et al.	
8,701,958 B2	4/2014	Shelton, IV et al.	
8,701,959 B2	4/2014	Shah	
8,708,213 B2	4/2014	Shelton, IV et al.	
8,720,766 B2	5/2014	Hess et al.	
8,721,666 B2	5/2014	Schroeder et al.	
8,727,197 B2	5/2014	Hess et al.	
8,733,613 B2	5/2014	Huitema et al.	
8,734,478 B2	5/2014	Widenhouse et al.	
8,746,529 B2	6/2014	Shelton, IV et al.	
8,746,530 B2	6/2014	Giordano et al.	
8,747,238 B2	6/2014	Shelton, IV et al.	
8,752,747 B2	6/2014	Shelton, IV et al.	
8,752,749 B2	6/2014	Moore et al.	
8,758,235 B2	6/2014	Jaworek	
8,758,391 B2	6/2014	Swayze et al.	
8,763,875 B2	7/2014	Morgan et al.	
8,763,879 B2	7/2014	Shelton, IV et al.	
8,783,541 B2	7/2014	Shelton, IV et al.	
8,783,543 B2	7/2014	Shelton, IV et al.	
8,784,404 B2	7/2014	Doyle et al.	
8,789,739 B2	7/2014	Swensgard	
8,789,740 B2	7/2014	Baxter, III et al.	
8,794,497 B2	8/2014	Zingman	
8,800,838 B2	8/2014	Shelton, IV	
8,800,841 B2	8/2014	Ellerhorst et al.	
8,801,734 B2	8/2014	Shelton, IV et al.	
8,801,735 B2	8/2014	Shelton, IV et al.	
8,820,603 B2	9/2014	Shelton, IV et al.	
8,820,605 B2	9/2014	Shelton, IV	
8,827,133 B2	9/2014	Shelton, IV et al.	
8,827,903 B2	9/2014	Shelton, IV et al.	
8,833,632 B2	9/2014	Swensgard	
8,840,603 B2	9/2014	Shelton, IV et al.	
8,844,789 B2	9/2014	Shelton, IV et al.	
8,851,354 B2	10/2014	Swensgard et al.	
8,857,693 B2	10/2014	Schuckmann et al.	
8,858,571 B2	10/2014	Shelton, IV et al.	
8,858,590 B2	10/2014	Shelton, IV et al.	
8,875,971 B2	11/2014	Hall et al.	
8,875,972 B2	11/2014	Weisenburgh, II et al.	
8,893,946 B2	11/2014	Boudreaux et al.	
8,899,465 B2	12/2014	Shelton, IV et al.	
8,899,466 B2	12/2014	Baxter, III et al.	
8,911,471 B2	12/2014	Spivey et al.	
8,925,788 B2	1/2015	Hess et al.	
8,926,598 B2	1/2015	Mollere et al.	
8,931,682 B2	1/2015	Timm et al.	
8,936,614 B2	1/2015	Allen, IV	
2001/0025183 A1	9/2001	Shahidi	
2001/0044637 A1	11/2001	Jacobs et al.	
2002/0022836 A1	2/2002	Goble et al.	
2002/0029036 A1	3/2002	Goble et al.	
2002/0095175 A1	7/2002	Brock et al.	
2002/0103494 A1	8/2002	Pacey	
2002/0117534 A1	8/2002	Green et al.	
2002/0134811 A1	9/2002	Napier et al.	
2002/0165541 A1	11/2002	Whitman	
2002/0193808 A1	12/2002	Belef et al.	
2003/0023316 A1*	1/2003	Brown et al.	623/23.72
2003/0078647 A1*	4/2003	Vallana et al.	623/1.11
2003/0084983 A1	5/2003	Rangachari et al.	
2003/0093103 A1	5/2003	Malackowski et al.	
2003/0096158 A1	5/2003	Takano et al.	
2003/0105478 A1	6/2003	Whitman et al.	
2003/0130677 A1	7/2003	Whitman et al.	
2003/0139741 A1	7/2003	Goble et al.	

(56) **References Cited**

U.S. PATENT DOCUMENTS

2003/0153908 A1 8/2003 Goble et al.
2003/0163085 A1 8/2003 Tanner et al.
2003/0181900 A1 9/2003 Long
2003/0195387 A1 10/2003 Kortenbach et al.
2003/0205029 A1 11/2003 Chapolini et al.
2003/0216732 A1 11/2003 Truckai et al.
2003/0220660 A1 11/2003 Kortenbach et al.
2003/0236505 A1 12/2003 Bonadio et al.
2004/0002726 A1 1/2004 Nunez et al.
2004/0006335 A1 1/2004 Garrison
2004/0006340 A1 1/2004 Latterell et al.
2004/0006372 A1 1/2004 Racenet et al.
2004/0006861 A1 1/2004 Haytayan
2004/0024457 A1* 2/2004 Boyce et al. 623/13.17
2004/0030333 A1 2/2004 Goble
2004/0034357 A1 2/2004 Beane et al.
2004/0034369 A1 2/2004 Sauer et al.
2004/0044364 A1 3/2004 DeVries et al.
2004/0068161 A1 4/2004 Couvillon, Jr.
2004/0068224 A1 4/2004 Couvillon, Jr. et al.
2004/0068307 A1 4/2004 Goble
2004/0070369 A1 4/2004 Sakahibara
2004/0073222 A1 4/2004 Koseki
2004/0078037 A1 4/2004 Batchelor et al.
2004/0093024 A1 5/2004 Lousararian et al.
2004/0094597 A1 5/2004 Whitman et al.
2004/0097987 A1 5/2004 Pugsley et al.
2004/0098040 A1 5/2004 Taniguchi et al.
2004/0101822 A1 5/2004 Wiesner et al.
2004/0102783 A1 5/2004 Sutterlin, III et al.
2004/0108357 A1 6/2004 Milliman et al.
2004/0111081 A1 6/2004 Whitman et al.
2004/0115022 A1 6/2004 Albertson et al.
2004/0116952 A1 6/2004 Sakurai et al.
2004/0147909 A1 7/2004 Johnston et al.
2004/0164123 A1 8/2004 Racenet et al.
2004/0167572 A1 8/2004 Roth et al.
2004/0173659 A1 9/2004 Green et al.
2004/0181219 A1 9/2004 Goble et al.
2004/0186470 A1 9/2004 Goble et al.
2004/0193189 A1 9/2004 Kortenbach et al.
2004/0199181 A1 10/2004 Knodel et al.
2004/0222268 A1 11/2004 Bilotti et al.
2004/0225186 A1 11/2004 Horne, Jr. et al.
2004/0230214 A1 11/2004 Donofrio et al.
2004/0232201 A1 11/2004 Wenchell et al.
2004/0236352 A1 11/2004 Wang et al.
2004/0243147 A1 12/2004 Lipow
2004/0243151 A1 12/2004 Demmy et al.
2004/0243163 A1 12/2004 Casiano et al.
2004/0243176 A1 12/2004 Hahnen et al.
2004/0247415 A1 12/2004 Mangone, Jr.
2004/0254566 A1 12/2004 Plicchi et al.
2004/0254608 A1 12/2004 Huitema et al.
2004/0260315 A1 12/2004 Dell et al.
2004/0267310 A1 12/2004 Racenet et al.
2004/0267362 A1* 12/2004 Hwang et al. 623/13.15
2005/0010213 A1 1/2005 Stad et al.
2005/0032511 A1 2/2005 Malone et al.
2005/0033357 A1 2/2005 Braun
2005/0054946 A1 3/2005 Krzyzanowski
2005/0059997 A1 3/2005 Bauman et al.
2005/0070929 A1 3/2005 Dalessandro et al.
2005/0075561 A1 4/2005 Golden
2005/0080454 A1 4/2005 Drews et al.
2005/0085693 A1 4/2005 Belson et al.
2005/0090817 A1 4/2005 Phan
2005/0096683 A1 5/2005 Ellins et al.
2005/0103819 A1 5/2005 Racenet et al.
2005/0107814 A1 5/2005 Johnston et al.
2005/0107824 A1 5/2005 Hillstead et al.
2005/0113820 A1 5/2005 Goble et al.
2005/0119525 A1 6/2005 Takemoto
2005/0119669 A1 6/2005 Demmy
2005/0124855 A1 6/2005 Jaffe et al.
2005/0125009 A1 6/2005 Perry et al.
2005/0125897 A1 6/2005 Wyslucha et al.
2005/0131173 A1 6/2005 McDaniel et al.
2005/0131211 A1 6/2005 Bayley et al.
2005/0131390 A1 6/2005 Heinrich et al.
2005/0131436 A1 6/2005 Johnston et al.
2005/0131437 A1 6/2005 Johnston et al.
2005/0131457 A1 6/2005 Douglas et al.
2005/0137454 A1 6/2005 Saadat et al.
2005/0137455 A1 6/2005 Ewers et al.
2005/0143759 A1 6/2005 Kelly
2005/0143769 A1 6/2005 White et al.
2005/0145675 A1 7/2005 Hartwick et al.
2005/0154258 A1 7/2005 Tartaglia et al.
2005/0154406 A1 7/2005 Bombard et al.
2005/0165419 A1 7/2005 Sauer et al.
2005/0165435 A1 7/2005 Johnston et al.
2005/0169974 A1 8/2005 Tenerz et al.
2005/0171522 A1 8/2005 Christopherson
2005/0177181 A1 8/2005 Kagan et al.
2005/0182298 A1 8/2005 Ikeda et al.
2005/0187545 A1 8/2005 Hooven et al.
2005/0187572 A1 8/2005 Johnston et al.
2005/0187576 A1 8/2005 Whitman et al.
2005/0189397 A1 9/2005 Jankowski
2005/0192609 A1 9/2005 Whitman et al.
2005/0192628 A1 9/2005 Viola
2005/0203550 A1 9/2005 Laufer et al.
2005/0216055 A1 9/2005 Scirica et al.
2005/0228224 A1 10/2005 Okada et al.
2005/0240178 A1 10/2005 Morley et al.
2005/0240222 A1 10/2005 Shipp
2005/0245965 A1 11/2005 Orban, III et al.
2005/0251128 A1 11/2005 Amoah
2005/0256452 A1 11/2005 DeMarchi et al.
2005/0256522 A1 11/2005 Francischelli et al.
2005/0261676 A1 11/2005 Hall et al.
2005/0261677 A1 11/2005 Hall et al.
2005/0263563 A1 12/2005 Racenet et al.
2005/0267455 A1 12/2005 Eggers et al.
2005/0274768 A1 12/2005 Cummins et al.
2005/0283188 A1 12/2005 Loshakove et al.
2006/0004407 A1 1/2006 Hiles et al.
2006/0008787 A1 1/2006 Hayman et al.
2006/0011699 A1 1/2006 Olson et al.
2006/0015009 A1 1/2006 Jaffe et al.
2006/0020247 A1 1/2006 Kagan et al.
2006/0020258 A1 1/2006 Strauss et al.
2006/0020336 A1 1/2006 Liddicoat
2006/0025811 A1 2/2006 Shelton, IV
2006/0025812 A1 2/2006 Shelton, IV
2006/0025813 A1 2/2006 Shelton et al.
2006/0041188 A1 2/2006 Dirusso et al.
2006/0047275 A1 3/2006 Goble
2006/0047303 A1 3/2006 Ortiz et al.
2006/0047307 A1 3/2006 Ortiz et al.
2006/0049229 A1 3/2006 Milliman et al.
2006/0052825 A1 3/2006 Ransick et al.
2006/0060630 A1 3/2006 Shelton, IV et al.
2006/0064086 A1 3/2006 Odom
2006/0079115 A1 4/2006 Aranyi et al.
2006/0079735 A1 4/2006 Martone et al.
2006/0085031 A1 4/2006 Bettuchi
2006/0085033 A1 4/2006 Criscuolo et al.
2006/0086032 A1 4/2006 Valencic et al.
2006/0087746 A1 4/2006 Lipow
2006/0089535 A1 4/2006 Raz et al.
2006/0100643 A1 5/2006 Laufer et al.
2006/0108393 A1 5/2006 Heinrich et al.
2006/0111711 A1 5/2006 Goble
2006/0111723 A1 5/2006 Chapolini et al.
2006/0122636 A1 6/2006 Bailly et al.
2006/0135992 A1* 6/2006 Bettuchi et al. 606/219
2006/0142772 A1 6/2006 Ralph et al.
2006/0149163 A1 7/2006 Hibner et al.
2006/0161185 A1 7/2006 Saadat et al.
2006/0167471 A1 7/2006 Phillips
2006/0173470 A1 8/2006 Oray et al.
2006/0178556 A1 8/2006 Hasser et al.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2006/0180634	A1	8/2006	Shelton, IV et al.
2006/0185682	A1	8/2006	Marczyk
2006/0200123	A1	9/2006	Ryan
2006/0201989	A1	9/2006	Ojeda
2006/0212069	A1	9/2006	Shelton, IV
2006/0217729	A1	9/2006	Eskridge et al.
2006/0226196	A1	10/2006	Hueil et al.
2006/0235368	A1	10/2006	Oz
2006/0235469	A1	10/2006	Viola
2006/0241655	A1	10/2006	Viola
2006/0241692	A1	10/2006	McGuckin, Jr. et al.
2006/0244460	A1	11/2006	Weaver
2006/0252993	A1	11/2006	Freed et al.
2006/0253069	A1	11/2006	Li et al.
2006/0258904	A1	11/2006	Stefanchik et al.
2006/0258910	A1	11/2006	Stefanchik et al.
2006/0259073	A1	11/2006	Miyamoto et al.
2006/0264927	A1	11/2006	Ryan
2006/0264929	A1	11/2006	Goble et al.
2006/0271042	A1	11/2006	Latterell et al.
2006/0271102	A1	11/2006	Bosshard et al.
2006/0278680	A1	12/2006	Viola et al.
2006/0278681	A1	12/2006	Viola et al.
2006/0284730	A1	12/2006	Schmid et al.
2006/0287576	A1	12/2006	Tsuji et al.
2006/0289602	A1	12/2006	Wales et al.
2006/0291981	A1	12/2006	Viola et al.
2007/0010838	A1	1/2007	Shelton, IV et al.
2007/0023476	A1	2/2007	Whitman et al.
2007/0023477	A1	2/2007	Whitman et al.
2007/0026039	A1	2/2007	Drumheller et al.
2007/0026040	A1	2/2007	Crawley et al.
2007/0027468	A1	2/2007	Wales et al.
2007/0027472	A1	2/2007	Hiles et al.
2007/0027551	A1	2/2007	Farnsworth et al.
2007/0034668	A1	2/2007	Holsten et al.
2007/0049966	A1	3/2007	Bonadio et al.
2007/0051375	A1	3/2007	Milliman
2007/0055219	A1	3/2007	Whitman et al.
2007/0066981	A1	3/2007	Meagher
2007/0070574	A1	3/2007	Nerheim et al.
2007/0073341	A1	3/2007	Smith
2007/0078484	A1	4/2007	Talarico et al.
2007/0083193	A1	4/2007	Werneth et al.
2007/0084897	A1	4/2007	Shelton, IV et al.
2007/0093869	A1	4/2007	Bloom et al.
2007/0102472	A1	5/2007	Shelton, IV
2007/0106113	A1	5/2007	Ravo
2007/0106317	A1	5/2007	Shelton, IV et al.
2007/0118175	A1	5/2007	Butler et al.
2007/0129605	A1	6/2007	Schaaf
2007/0135686	A1	6/2007	Pruitt, Jr. et al.
2007/0135803	A1	6/2007	Belson
2007/0155010	A1 *	7/2007	Farnsworth et al. 435/399
2007/0158358	A1	7/2007	Mason, II et al.
2007/0170225	A1	7/2007	Shelton, IV et al.
2007/0173687	A1	7/2007	Shima et al.
2007/0173806	A1	7/2007	Orszulak et al.
2007/0173813	A1	7/2007	Odom
2007/0175950	A1	8/2007	Shelton, IV et al.
2007/0175951	A1	8/2007	Shelton, IV et al.
2007/0175955	A1	8/2007	Shelton, IV et al.
2007/0179528	A1	8/2007	Soltz et al.
2007/0181632	A1	8/2007	Milliman
2007/0194079	A1	8/2007	Hueil et al.
2007/0194082	A1	8/2007	Morgan et al.
2007/0203510	A1	8/2007	Bettuchi
2007/0213750	A1	9/2007	Weadock
2007/0219571	A1	9/2007	Balbierz et al.
2007/0221700	A1	9/2007	Ortiz et al.
2007/0225562	A1	9/2007	Spivey et al.
2007/0233163	A1	10/2007	Bombard et al.
2007/0239028	A1	10/2007	Houser et al.
2007/0243227	A1	10/2007	Gertner
2007/0244471	A1	10/2007	Malackowski
2007/0246505	A1	10/2007	Pace-Floridia et al.
2007/0249999	A1	10/2007	Sklar et al.
2007/0260278	A1	11/2007	Wheeler et al.
2007/0270784	A1	11/2007	Smith et al.
2007/0270884	A1	11/2007	Smith et al.
2007/0276409	A1	11/2007	Ortiz et al.
2007/0279011	A1	12/2007	Jones et al.
2007/0286892	A1	12/2007	Herzberg et al.
2007/0287993	A1	12/2007	Hinman et al.
2007/0288044	A1	12/2007	Jinno et al.
2007/0299427	A1	12/2007	Yeung et al.
2008/0015598	A1	1/2008	Prommersberger
2008/0029570	A1	2/2008	Shelton et al.
2008/0029573	A1	2/2008	Shelton et al.
2008/0029574	A1	2/2008	Shelton et al.
2008/0029575	A1	2/2008	Shelton et al.
2008/0030170	A1	2/2008	Dacquay et al.
2008/0035701	A1	2/2008	Racenet et al.
2008/0041916	A1	2/2008	Milliman et al.
2008/0041917	A1	2/2008	Racenet et al.
2008/0078802	A1	4/2008	Hess et al.
2008/0082114	A1	4/2008	McKenna et al.
2008/0082125	A1	4/2008	Murray et al.
2008/0082126	A1	4/2008	Murray et al.
2008/0083808	A1	4/2008	Scirica
2008/0083813	A1	4/2008	Zemlok et al.
2008/0085296	A1	4/2008	Powell et al.
2008/0086078	A1	4/2008	Powell et al.
2008/0114315	A1	5/2008	Voegele et al.
2008/0114385	A1	5/2008	Byrum et al.
2008/0128469	A1	6/2008	Dalessandro et al.
2008/0129253	A1	6/2008	Shiue et al.
2008/0140115	A1	6/2008	Stopek
2008/0154299	A1	6/2008	Livneh
2008/0169328	A1	7/2008	Shelton
2008/0169332	A1	7/2008	Shelton et al.
2008/0169333	A1	7/2008	Shelton et al.
2008/0172087	A1	7/2008	Fuchs et al.
2008/0172088	A1	7/2008	Smith et al.
2008/0183193	A1	7/2008	Omori et al.
2008/0185419	A1	8/2008	Smith et al.
2008/0190989	A1	8/2008	Crews et al.
2008/0197167	A1	8/2008	Viola et al.
2008/0200762	A1	8/2008	Stokes et al.
2008/0200835	A1	8/2008	Monson et al.
2008/0200933	A1	8/2008	Bakos et al.
2008/0200949	A1	8/2008	Hiles et al.
2008/0228029	A1	9/2008	Mikkaichi et al.
2008/0245841	A1	10/2008	Smith et al.
2008/0251568	A1	10/2008	Zemlok et al.
2008/0251569	A1	10/2008	Smith et al.
2008/0255413	A1	10/2008	Zemlok et al.
2008/0255607	A1	10/2008	Zemlok
2008/0262654	A1	10/2008	Omori et al.
2008/0283570	A1	11/2008	Boyden et al.
2008/0287944	A1	11/2008	Pearson et al.
2008/0290134	A1	11/2008	Bettuchi et al.
2008/0294179	A1	11/2008	Balbierz et al.
2008/0296346	A1	12/2008	Shelton, IV et al.
2008/0297287	A1	12/2008	Shachar et al.
2008/0308602	A1	12/2008	Timm et al.
2008/0308603	A1	12/2008	Shelton, IV et al.
2008/0308608	A1	12/2008	Prommersberger
2008/0314960	A1	12/2008	Marczyk et al.
2008/0315829	A1	12/2008	Jones et al.
2009/0001121	A1	1/2009	Hess et al.
2009/0001122	A1	1/2009	Prommersberger et al.
2009/0001130	A1	1/2009	Hess et al.
2009/0005807	A1	1/2009	Hess et al.
2009/0005809	A1	1/2009	Hess et al.
2009/0012534	A1	1/2009	Madhani et al.
2009/0018553	A1	1/2009	McLean et al.
2009/0020958	A1	1/2009	Soul
2009/0047329	A1	2/2009	Stucky et al.
2009/0048589	A1	2/2009	Takashino et al.
2009/0048612	A1	2/2009	Farritor et al.
2009/0054908	A1	2/2009	Zand et al.
2009/0076506	A1	3/2009	Baker
2009/0078736	A1	3/2009	Van Lue

(56) **References Cited**

U.S. PATENT DOCUMENTS

2009/0082789	A1	3/2009	Milliman et al.
2009/0088774	A1	4/2009	Swarup et al.
2009/0090763	A1	4/2009	Zemlok et al.
2009/0092651	A1	4/2009	Shah et al.
2009/0093728	A1	4/2009	Hyde et al.
2009/0099579	A1	4/2009	Nentwick et al.
2009/0099876	A1	4/2009	Whitman
2009/0108048	A1	4/2009	Zemlok et al.
2009/0112229	A1	4/2009	Omori et al.
2009/0114701	A1	5/2009	Zemlok et al.
2009/0119011	A1	5/2009	Kondo et al.
2009/0143805	A1	6/2009	Palmer et al.
2009/0143855	A1	6/2009	Weber et al.
2009/0149871	A9	6/2009	Kagan et al.
2009/0157067	A1	6/2009	Kane et al.
2009/0157087	A1	6/2009	Wei et al.
2009/0171147	A1	7/2009	Lee et al.
2009/0177226	A1	7/2009	Reinprecht et al.
2009/0188964	A1	7/2009	Orlov
2009/0198272	A1	8/2009	Kerver et al.
2009/0204108	A1	8/2009	Steffen
2009/0206125	A1	8/2009	Huitema et al.
2009/0206126	A1	8/2009	Huitema et al.
2009/0206131	A1	8/2009	Weisenburgh, II et al.
2009/0206133	A1	8/2009	Morgan et al.
2009/0206137	A1	8/2009	Hall et al.
2009/0206139	A1	8/2009	Hall et al.
2009/0206141	A1	8/2009	Huitema et al.
2009/0206142	A1	8/2009	Huitema et al.
2009/0213685	A1	8/2009	Mak et al.
2009/0242610	A1	10/2009	Shelton, IV et al.
2009/0247901	A1	10/2009	Zimmer
2009/0255974	A1	10/2009	Viola
2009/0255975	A1	10/2009	Zemlok et al.
2009/0255976	A1	10/2009	Marczyk et al.
2009/0255977	A1	10/2009	Zemlok
2009/0255978	A1	10/2009	Viola et al.
2009/0270895	A1	10/2009	Churchill et al.
2009/0277947	A1*	11/2009	Viola 227/176.1
2009/0277949	A1	11/2009	Viola et al.
2009/0292283	A1	11/2009	Odom
2009/0308907	A1	12/2009	Nalagatla et al.
2010/0010511	A1	1/2010	Harris et al.
2010/0012704	A1	1/2010	Tarinelli Racenet et al.
2010/0023024	A1	1/2010	Zeiner et al.
2010/0036370	A1	2/2010	Mirel et al.
2010/0049084	A1	2/2010	Nock et al.
2010/0057087	A1	3/2010	Cha
2010/0057107	A1	3/2010	Sorrentino et al.
2010/0069942	A1	3/2010	Shelton, IV
2010/0072254	A1	3/2010	Aranyi et al.
2010/0076475	A1	3/2010	Yates et al.
2010/0076483	A1	3/2010	Imuta
2010/0076489	A1	3/2010	Stopek et al.
2010/0087840	A1	4/2010	Ebersole et al.
2010/0094289	A1	4/2010	Taylor et al.
2010/0096431	A1	4/2010	Smith et al.
2010/0100124	A1	4/2010	Calabrese et al.
2010/0108740	A1	5/2010	Pastorelli et al.
2010/0108741	A1	5/2010	Hessler et al.
2010/0133317	A1	6/2010	Shelton, IV et al.
2010/0145146	A1	6/2010	Melder
2010/0147921	A1	6/2010	Olson
2010/0147922	A1	6/2010	Olson
2010/0147923	A1	6/2010	D'Agostino et al.
2010/0163598	A1	7/2010	Belzer
2010/0179022	A1	7/2010	Shirokoshi
2010/0179540	A1	7/2010	Marczyk et al.
2010/0186219	A1	7/2010	Smith
2010/0193566	A1	8/2010	Scheib et al.
2010/0200637	A1	8/2010	Beetel
2010/0204717	A1	8/2010	Knodel
2010/0222901	A1	9/2010	Swayze et al.
2010/0230465	A1	9/2010	Smith et al.
2010/0243707	A1	9/2010	Olson et al.
2010/0243708	A1	9/2010	Aranyi et al.
2010/0249519	A1	9/2010	Park et al.
2010/0258611	A1	10/2010	Smith et al.
2010/0267662	A1	10/2010	Fielder et al.
2010/0268030	A1	10/2010	Viola et al.
2010/0274160	A1	10/2010	Yachi et al.
2010/0276471	A1	11/2010	Whitman
2010/0292540	A1	11/2010	Hess et al.
2010/0294827	A1	11/2010	Boyden et al.
2010/0298636	A1	11/2010	Casto et al.
2010/0305552	A1	12/2010	Shelton, IV et al.
2010/0312261	A1	12/2010	Suzuki et al.
2010/0320252	A1	12/2010	Viola et al.
2010/0331856	A1	12/2010	Carlson et al.
2010/0331880	A1	12/2010	Stopek
2011/0003528	A1	1/2011	Lam
2011/0006099	A1	1/2011	Hall et al.
2011/0006101	A1	1/2011	Hall et al.
2011/0011916	A1	1/2011	Levine
2011/0017799	A1	1/2011	Whitman et al.
2011/0017801	A1	1/2011	Zemlok et al.
2011/0022032	A1	1/2011	Zemlok et al.
2011/0024477	A1	2/2011	Hall et al.
2011/0024478	A1	2/2011	Shelton, IV
2011/0024479	A1	2/2011	Swensgard et al.
2011/0034918	A1	2/2011	Reschke
2011/0036887	A1	2/2011	Zemlok et al.
2011/0036890	A1	2/2011	Ma
2011/0036891	A1	2/2011	Zemlok et al.
2011/0045047	A1	2/2011	Bennett et al.
2011/0060363	A1	3/2011	Hess et al.
2011/0084112	A1	4/2011	Kostrzewski
2011/0087276	A1	4/2011	Bedi et al.
2011/0087279	A1	4/2011	Shah et al.
2011/0095068	A1	4/2011	Patel
2011/0101065	A1	5/2011	Milliman
2011/0114697	A1	5/2011	Baxter, III et al.
2011/0118754	A1	5/2011	Dachs, II et al.
2011/0118778	A1	5/2011	Burbank
2011/0125176	A1	5/2011	Yates et al.
2011/0125177	A1	5/2011	Yates et al.
2011/0144430	A1	6/2011	Spivey et al.
2011/0144640	A1	6/2011	Heinrich et al.
2011/0147433	A1	6/2011	Shelton, IV et al.
2011/0155786	A1	6/2011	Shelton, IV
2011/0155787	A1	6/2011	Baxter, III et al.
2011/0163146	A1	7/2011	Ortiz et al.
2011/0174099	A1	7/2011	Ross et al.
2011/0174861	A1	7/2011	Shelton, IV et al.
2011/0178536	A1	7/2011	Kostrzewski
2011/0184459	A1	7/2011	Malkowski et al.
2011/0192882	A1	8/2011	Hess et al.
2011/0210156	A1	9/2011	Smith et al.
2011/0253765	A1	10/2011	Nicholas et al.
2011/0275901	A1	11/2011	Shelton, IV
2011/0276083	A1	11/2011	Shelton, IV et al.
2011/0278343	A1	11/2011	Knodel et al.
2011/0282446	A1	11/2011	Schulte et al.
2011/0288573	A1	11/2011	Yates et al.
2011/0290851	A1	12/2011	Shelton, IV
2011/0290853	A1	12/2011	Shelton, IV et al.
2011/0290856	A1	12/2011	Shelton, IV et al.
2011/0293690	A1	12/2011	Griffin et al.
2011/0295242	A1	12/2011	Spivey et al.
2011/0295269	A1	12/2011	Swensgard et al.
2011/0295295	A1	12/2011	Shelton, IV et al.
2011/0315413	A1	12/2011	Fisher et al.
2012/0004636	A1	1/2012	Lo
2012/0022523	A1	1/2012	Smith et al.
2012/0022630	A1	1/2012	Wübbeling
2012/0029272	A1	2/2012	Shelton, IV et al.
2012/0046692	A1	2/2012	Smith et al.
2012/0071711	A1	3/2012	Shelton, IV et al.
2012/0074200	A1	3/2012	Schmid et al.
2012/0074201	A1	3/2012	Baxter, III et al.
2012/0080332	A1	4/2012	Shelton, IV et al.
2012/0080335	A1	4/2012	Shelton, IV et al.
2012/0080336	A1	4/2012	Shelton, IV et al.
2012/0080337	A1	4/2012	Shelton, IV et al.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2012/0080338	A1	4/2012	Shelton, IV et al.
2012/0080339	A1	4/2012	Shelton, IV et al.
2012/0080340	A1	4/2012	Shelton, IV et al.
2012/0080344	A1	4/2012	Shelton, IV
2012/0080345	A1	4/2012	Morgan et al.
2012/0080475	A1	4/2012	Smith et al.
2012/0080478	A1	4/2012	Morgan et al.
2012/0080479	A1	4/2012	Shelton, IV
2012/0080480	A1	4/2012	Woodard, Jr. et al.
2012/0080481	A1	4/2012	Widenhouse et al.
2012/0080482	A1	4/2012	Schall et al.
2012/0080483	A1	4/2012	Riestenberg et al.
2012/0080484	A1	4/2012	Morgan et al.
2012/0080485	A1	4/2012	Woodard, Jr. et al.
2012/0080486	A1	4/2012	Woodard, Jr. et al.
2012/0080488	A1	4/2012	Shelton, IV et al.
2012/0080489	A1	4/2012	Shelton, IV et al.
2012/0080490	A1	4/2012	Shelton, IV et al.
2012/0080491	A1	4/2012	Shelton, IV et al.
2012/0080493	A1	4/2012	Shelton, IV et al.
2012/0080496	A1	4/2012	Schall et al.
2012/0080498	A1	4/2012	Shelton, IV et al.
2012/0080499	A1	4/2012	Schall et al.
2012/0080500	A1	4/2012	Morgan et al.
2012/0080501	A1	4/2012	Morgan et al.
2012/0080502	A1	4/2012	Morgan et al.
2012/0080503	A1	4/2012	Woodard, Jr. et al.
2012/0083833	A1	4/2012	Shelton, IV et al.
2012/0083834	A1	4/2012	Shelton, IV et al.
2012/0083835	A1	4/2012	Shelton, IV et al.
2012/0083836	A1	4/2012	Shelton, IV et al.
2012/0089131	A1	4/2012	Zemlok et al.
2012/0138658	A1	6/2012	Ullrich et al.
2012/0150192	A1	6/2012	Dachs, II et al.
2012/0160721	A1	6/2012	Shelton, IV et al.
2012/0175398	A1	7/2012	Sandborn et al.
2012/0187179	A1	7/2012	Gleiman
2012/0199632	A1	8/2012	Spivey et al.
2012/0209289	A1	8/2012	Duque et al.
2012/0223123	A1	9/2012	Baxter, III et al.
2012/0234890	A1	9/2012	Aronhalt et al.
2012/0234891	A1	9/2012	Aronhalt et al.
2012/0234892	A1	9/2012	Aronhalt et al.
2012/0234895	A1	9/2012	O'Connor et al.
2012/0234897	A1	9/2012	Shelton, IV et al.
2012/0234898	A1	9/2012	Shelton, IV et al.
2012/0234899	A1	9/2012	Scheib et al.
2012/0238823	A1	9/2012	Hagerty et al.
2012/0238824	A1	9/2012	Widenhouse et al.
2012/0239010	A1	9/2012	Shelton, IV et al.
2012/0241491	A1	9/2012	Aldridge et al.
2012/0241492	A1	9/2012	Shelton, IV et al.
2012/0241493	A1	9/2012	Baxter, III et al.
2012/0241496	A1	9/2012	Mandakolathur Vasudevan et al.
2012/0241497	A1	9/2012	Mandakolathur Vasudevan et al.
2012/0241498	A1	9/2012	Gonzalez et al.
2012/0241499	A1	9/2012	Baxter, III et al.
2012/0241500	A1	9/2012	Timmer et al.
2012/0241502	A1	9/2012	Aldridge et al.
2012/0241503	A1	9/2012	Baxter, III et al.
2012/0241505	A1	9/2012	Alexander, III et al.
2012/0248169	A1	10/2012	Widenhouse et al.
2012/0253298	A1	10/2012	Henderson et al.
2012/0253329	A1	10/2012	Zemlok et al.
2012/0265176	A1	10/2012	Braun
2012/0273550	A1	11/2012	Scirica
2012/0283707	A1	11/2012	Giordano et al.
2012/0283748	A1	11/2012	Ortiz et al.
2012/0289979	A1	11/2012	Eskaros et al.
2012/0292367	A1	11/2012	Morgan et al.
2012/0296333	A1	11/2012	Twomey
2012/0298719	A1	11/2012	Shelton, IV et al.
2012/0298722	A1	11/2012	Hess et al.
2012/0310255	A1	12/2012	Brisson et al.
2012/0310256	A1	12/2012	Brisson
2012/0312860	A1	12/2012	Ming et al.
2012/0318842	A1	12/2012	Anim et al.
2012/0318843	A1	12/2012	Henderson et al.
2012/0318844	A1	12/2012	Shelton, IV et al.
2012/0325892	A1	12/2012	Kostrzewski
2013/0018361	A1	1/2013	Bryant
2013/0020375	A1	1/2013	Shelton, IV et al.
2013/0020376	A1	1/2013	Shelton, IV et al.
2013/0023861	A1	1/2013	Shelton, IV et al.
2013/0026208	A1	1/2013	Shelton, IV et al.
2013/0026210	A1	1/2013	Shelton, IV et al.
2013/0032626	A1	2/2013	Smith et al.
2013/0037596	A1	2/2013	Bear et al.
2013/0048697	A1	2/2013	Shelton, IV et al.
2013/0056518	A1	3/2013	Swensgard
2013/0056521	A1	3/2013	Swensgard
2013/0062391	A1	3/2013	Boudreaux et al.
2013/0075448	A1	3/2013	Schmid et al.
2013/0075449	A1	3/2013	Schmid et al.
2013/0075450	A1	3/2013	Schmid et al.
2013/0079814	A1	3/2013	Hess et al.
2013/0087597	A1	4/2013	Shelton, IV et al.
2013/0087599	A1	4/2013	Krumanaker et al.
2013/0087602	A1	4/2013	Olson et al.
2013/0098970	A1	4/2013	Racenet et al.
2013/0103024	A1	4/2013	Monson et al.
2013/0116668	A1	5/2013	Shelton, IV et al.
2013/0116669	A1	5/2013	Shelton, IV et al.
2013/0119108	A1	5/2013	Altman et al.
2013/0123822	A1	5/2013	Wellman et al.
2013/0126581	A1	5/2013	Yates et al.
2013/0126582	A1	5/2013	Shelton, IV et al.
2013/0146641	A1	6/2013	Shelton, IV et al.
2013/0146642	A1	6/2013	Shelton, IV et al.
2013/0146643	A1	6/2013	Schmid et al.
2013/0150832	A1	6/2013	Belson et al.
2013/0153633	A1	6/2013	Casasanta, Jr. et al.
2013/0153634	A1	6/2013	Carter et al.
2013/0153636	A1	6/2013	Shelton, IV et al.
2013/0153638	A1	6/2013	Carter et al.
2013/0153641	A1	6/2013	Shelton, IV et al.
2013/0161374	A1	6/2013	Swayze et al.
2013/0161375	A1	6/2013	Huitema et al.
2013/0168435	A1	7/2013	Huang et al.
2013/0172929	A1	7/2013	Hess et al.
2013/0175317	A1	7/2013	Yates et al.
2013/0175322	A1	7/2013	Yates et al.
2013/0181033	A1	7/2013	Shelton, IV et al.
2013/0181034	A1	7/2013	Shelton, IV et al.
2013/0184718	A1	7/2013	Smith et al.
2013/0184719	A1	7/2013	Shelton, IV et al.
2013/0186932	A1	7/2013	Shelton, IV et al.
2013/0186933	A1	7/2013	Shelton, IV et al.
2013/0186934	A1	7/2013	Shelton, IV et al.
2013/0186936	A1	7/2013	Shelton, IV
2013/0190733	A1	7/2013	Giordano et al.
2013/0190757	A1	7/2013	Yates et al.
2013/0193188	A1	8/2013	Shelton, IV et al.
2013/0193189	A1	8/2013	Swensgard et al.
2013/0197556	A1	8/2013	Shelton, IV et al.
2013/0200132	A1	8/2013	Moore et al.
2013/0206814	A1	8/2013	Morgan et al.
2013/0214030	A1	8/2013	Aronhalt et al.
2013/0221063	A1	8/2013	Aronhalt et al.
2013/0221064	A1	8/2013	Aronhalt et al.
2013/0221065	A1	8/2013	Aronhalt et al.
2013/0233906	A1	9/2013	Hess et al.
2013/0248576	A1	9/2013	Laurent et al.
2013/0248577	A1	9/2013	Leimbach et al.
2013/0256365	A1	10/2013	Shelton, IV et al.
2013/0256366	A1	10/2013	Shelton, IV et al.
2013/0256367	A1	10/2013	Scheib et al.
2013/0256368	A1	10/2013	Timm et al.
2013/0256369	A1	10/2013	Schmid et al.
2013/0256371	A1	10/2013	Shelton, IV et al.
2013/0256372	A1	10/2013	Baxter, III et al.
2013/0256373	A1	10/2013	Schmid et al.
2013/0256374	A1	10/2013	Shelton, IV et al.
2013/0256375	A1	10/2013	Shelton, IV et al.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2013/0256376	A1	10/2013	Barton et al.
2013/0256377	A1	10/2013	Schmid et al.
2013/0256378	A1	10/2013	Schmid et al.
2013/0256379	A1	10/2013	Schmid et al.
2013/0256380	A1	10/2013	Schmid et al.
2013/0256382	A1	10/2013	Swayze et al.
2013/0256383	A1	10/2013	Aronhalt et al.
2013/0261648	A1	10/2013	Laurent et al.
2013/0270322	A1	10/2013	Scheib et al.
2013/0277412	A1	10/2013	Gresham et al.
2013/0310873	A1	11/2013	Stopek et al.
2013/0313303	A1	11/2013	Shelton, IV et al.
2013/0313304	A1	11/2013	Shelton, IV et al.
2013/0313306	A1	11/2013	Shelton, IV et al.
2013/0324981	A1	12/2013	Smith et al.
2013/0324982	A1	12/2013	Smith et al.
2013/0327809	A1	12/2013	Shelton, IV et al.
2013/0327810	A1	12/2013	Swayze et al.
2013/0334278	A1	12/2013	Kerr et al.
2013/0334283	A1	12/2013	Swayze et al.
2013/0334284	A1	12/2013	Swayze et al.
2013/0334285	A1	12/2013	Swayze et al.
2013/0334286	A1	12/2013	Swayze et al.
2013/0334287	A1	12/2013	Shelton, IV
2013/0334288	A1	12/2013	Shelton, IV
2013/0341374	A1	12/2013	Shelton, IV et al.
2014/0000411	A1	1/2014	Shelton, IV et al.
2014/0001231	A1	1/2014	Shelton, IV et al.
2014/0001234	A1	1/2014	Shelton, IV et al.
2014/0001235	A1	1/2014	Shelton, IV
2014/0001236	A1	1/2014	Shelton, IV et al.
2014/0001237	A1	1/2014	Shelton, IV et al.
2014/0001238	A1	1/2014	Shelton, IV et al.
2014/0001239	A1	1/2014	Shelton, IV et al.
2014/0001240	A1	1/2014	Shelton, IV et al.
2014/0005640	A1	1/2014	Shelton, IV et al.
2014/0005653	A1	1/2014	Shelton, IV et al.
2014/0005661	A1	1/2014	Shelton, IV et al.
2014/0005662	A1	1/2014	Shelton, IV
2014/0005676	A1	1/2014	Shelton, IV et al.
2014/0005678	A1	1/2014	Shelton, IV et al.
2014/0005679	A1	1/2014	Shelton, IV et al.
2014/0005680	A1	1/2014	Shelton, IV et al.
2014/0005693	A1	1/2014	Shelton, IV et al.
2014/0005694	A1	1/2014	Shelton, IV et al.
2014/0005695	A1	1/2014	Shelton, IV
2014/0005702	A1	1/2014	Timm et al.
2014/0005703	A1	1/2014	Stulen et al.
2014/0005708	A1	1/2014	Shelton, IV
2014/0005718	A1	1/2014	Shelton, IV et al.
2014/0008414	A1	1/2014	Shelton, IV et al.
2014/0014705	A1	1/2014	Baxter, III
2014/0042205	A1	2/2014	Baxter, III et al.
2014/0048582	A1	2/2014	Shelton, IV et al.
2014/0061279	A1	3/2014	Laurent et al.
2014/0097227	A1	4/2014	Aronhalt et al.
2014/0107640	A1	4/2014	Yates et al.
2014/0128850	A1	5/2014	Kerr et al.
2014/0151433	A1	6/2014	Shelton, IV et al.
2014/0151434	A1	6/2014	Shelton, IV et al.
2014/0166722	A1	6/2014	Hess et al.
2014/0166724	A1	6/2014	Schellin et al.
2014/0166725	A1	6/2014	Schellin et al.
2014/0166726	A1	6/2014	Schellin et al.
2014/0171966	A1	6/2014	Giordano et al.
2014/0175152	A1	6/2014	Hess et al.
2014/0175154	A1	6/2014	Shelton, IV et al.
2014/0175155	A1	6/2014	Shelton, IV et al.
2014/0191014	A1	7/2014	Shelton, IV
2014/0191015	A1	7/2014	Shelton, IV
2014/0197223	A1	7/2014	Hess et al.
2014/0205637	A1	7/2014	Widenhouse et al.
2014/0207166	A1	7/2014	Shelton, IV et al.
2014/0224686	A1	8/2014	Aronhalt et al.
2014/0224857	A1	8/2014	Schmid
2014/0236184	A1	8/2014	Leimbach et al.
2014/0243865	A1	8/2014	Swayze et al.
2014/0246471	A1	9/2014	Jaworek et al.
2014/0246472	A1	9/2014	Kimsey et al.
2014/0246473	A1	9/2014	Auld
2014/0246474	A1	9/2014	Hall et al.
2014/0246475	A1	9/2014	Hall et al.
2014/0246476	A1	9/2014	Hall et al.
2014/0246477	A1	9/2014	Koch, Jr. et al.
2014/0246478	A1	9/2014	Baber et al.
2014/0246479	A1	9/2014	Baber et al.
2014/0249557	A1	9/2014	Koch, Jr. et al.
2014/0252066	A1	9/2014	Shelton, IV et al.
2014/0252067	A1	9/2014	Moore et al.
2014/0252068	A1	9/2014	Shelton, IV et al.
2014/0252069	A1	9/2014	Moore et al.
2014/0252071	A1	9/2014	Moore et al.
2014/0259591	A1	9/2014	Shelton, IV et al.
2014/0263537	A1	9/2014	Leimbach et al.
2014/0263538	A1	9/2014	Leimbach et al.
2014/0263539	A1	9/2014	Leimbach et al.
2014/0263541	A1	9/2014	Leimbach et al.
2014/0263542	A1	9/2014	Leimbach et al.
2014/0263543	A1	9/2014	Leimbach et al.
2014/0263551	A1	9/2014	Hall et al.
2014/0263552	A1	9/2014	Hall et al.
2014/0263553	A1	9/2014	Leimbach et al.
2014/0263554	A1	9/2014	Leimbach et al.
2014/0263564	A1	9/2014	Leimbach et al.
2014/0263565	A1	9/2014	Lytle, IV et al.
2014/0263571	A1	9/2014	Morgan et al.
2014/0263572	A1	9/2014	Shelton, IV et al.
2014/0277017	A1	9/2014	Leimbach et al.
2014/0284371	A1	9/2014	Morgan et al.
2014/0284373	A1	9/2014	Shelton, IV et al.
2014/0291378	A1	10/2014	Shelton, IV et al.
2014/0291379	A1	10/2014	Schellin et al.
2014/0291380	A1	10/2014	Weaner et al.
2014/0291381	A1	10/2014	Weaner et al.
2014/0291382	A1	10/2014	Lloyd et al.
2014/0291383	A1	10/2014	Spivey et al.
2014/0296873	A1	10/2014	Morgan et al.
2014/0296874	A1	10/2014	Morgan et al.
2014/0299648	A1	10/2014	Shelton, IV et al.
2014/0299649	A1	10/2014	Shelton, IV et al.
2014/0303645	A1	10/2014	Morgan et al.
2014/0303646	A1	10/2014	Morgan et al.
2014/0305986	A1	10/2014	Hall et al.
2014/0305987	A1	10/2014	Parihar et al.
2014/0305988	A1	10/2014	Boudreaux et al.
2014/0305989	A1	10/2014	Parihar et al.
2014/0305990	A1	10/2014	Shelton, IV et al.
2014/0305991	A1	10/2014	Parihar et al.
2014/0305992	A1	10/2014	Kimsey et al.
2014/0305993	A1	10/2014	Timm et al.
2014/0305994	A1	10/2014	Parihar et al.
2014/0305995	A1	10/2014	Shelton, IV et al.
2014/0309665	A1	10/2014	Parihar et al.
2014/0309666	A1	10/2014	Shelton, IV et al.
2014/0326777	A1	11/2014	Zingman
2014/0330161	A1	11/2014	Swayze et al.
2014/0352463	A1	12/2014	Parihar
2014/0353358	A1	12/2014	Shelton, IV et al.
2014/0353359	A1	12/2014	Hall et al.
2014/0367447	A1	12/2014	Woodard, Jr. et al.
2015/0008248	A1	1/2015	Giordano et al.
2015/0034696	A1	2/2015	Shelton, IV et al.
2015/0038986	A1	2/2015	Swensgard et al.
2015/0041518	A1	2/2015	Shelton, IV et al.

FOREIGN PATENT DOCUMENTS

AU	2012200178	B2	7/2013
CA	2458946	A1	3/2003
CA	2512960	A1	1/2006
CA	2514274	A1	1/2006
CA	2639177	A1	2/2009
CN	2488482	Y	5/2002
CN	1523725	A	8/2004

(56) **References Cited**

FOREIGN PATENT DOCUMENTS

CN	1634601	A	7/2005
CN	1726874	A	2/2006
CN	1868411	A	11/2006
CN	1915180	A	2/2007
CN	1960679	A	5/2007
CN	101011286	A	8/2007
CN	101095621	A	1/2008
CN	101023879	B	3/2013
DE	273689	C	5/1914
DE	1775926	A	1/1972
DE	3036217	A1	4/1982
DE	3212828	A1	11/1982
DE	3210466	A1	9/1983
DE	3709067	A1	9/1988
DE	9412228	U	9/1994
DE	19509116	A1	9/1996
DE	19851291	A1	1/2000
DE	19924311	A1	11/2000
DE	69328576	T2	1/2001
DE	20016423	U1	2/2001
DE	10052679	A1	5/2001
DE	20112837	U1	10/2001
DE	20121753	U1	4/2003
DE	10314072	A1	10/2004
DE	202007003114	U1	6/2007
EP	0000756	A1	2/1979
EP	0122046	A1	10/1984
EP	0070230	B1	10/1985
EP	0156774	A2	10/1985
EP	0387980	B1	10/1985
EP	0033548	B1	5/1986
EP	0077262	B1	8/1986
EP	0129442	B1	11/1987
EP	0276104	A2	7/1988
EP	0178940	B1	1/1991
EP	0178941	B1	1/1991
EP	0169044	B1	6/1991
EP	0248844	B1	1/1993
EP	0539762	A1	5/1993
EP	0545029	A1	6/1993
EP	0277959	B1	10/1993
EP	0591946	A1	10/1993
EP	0233940	B1	11/1993
EP	0261230	B1	11/1993
EP	0639349	A2	2/1994
EP	0324636	B1	3/1994
EP	0593920	A1	4/1994
EP	0594148	A1	4/1994
EP	0427949	B1	6/1994
EP	0523174	B1	6/1994
EP	0600182	A2	6/1994
EP	0310431	B1	11/1994
EP	0375302	B1	11/1994
EP	0376562	B1	11/1994
EP	0630612	A1	12/1994
EP	0634144	A1	1/1995
EP	0646356	A2	4/1995
EP	0646357	A1	4/1995
EP	0505036	B1	5/1995
EP	0653189	A2	5/1995
EP	0669104	A1	8/1995
EP	0511470	B1	10/1995
EP	0674876	A2	10/1995
EP	0679367	A2	11/1995
EP	0392547	B1	12/1995
EP	0685204	A1	12/1995
EP	0364216	B1	1/1996
EP	0699418	A1	3/1996
EP	0702937	A1	3/1996
EP	0705571	A1	4/1996
EP	0711611	A2	5/1996
EP	0484677	B2	6/1996
EP	0541987	B1	7/1996
EP	0667119	B1	7/1996
EP	0737446	A1	10/1996
EP	0748614	A1	12/1996
EP	0708618	B1	3/1997
EP	0770355	A1	5/1997
EP	0503662	B1	6/1997
EP	0447121	B1	7/1997
EP	0621009	B1	7/1997
EP	0625077	B1	7/1997
EP	0633749	B1	8/1997
EP	0710090	B1	8/1997
EP	0578425	B1	9/1997
EP	0625335	B1	11/1997
EP	0552423	B1	1/1998
EP	0592244	B1	1/1998
EP	0648476	B1	1/1998
EP	0649290	B1	3/1998
EP	0598618	B1	9/1998
EP	0676173	B1	9/1998
EP	0678007	B1	9/1998
EP	0869104	A1	10/1998
EP	0603472	B1	11/1998
EP	0605351	B1	11/1998
EP	0878169	A1	11/1998
EP	0879742	A1	11/1998
EP	0695144	B1	12/1998
EP	0722296	B1	12/1998
EP	0760230	B1	2/1999
EP	0623316	B1	3/1999
EP	0650701	B1	3/1999
EP	0537572	B1	6/1999
EP	0923907	A1	6/1999
EP	0640317	A1	9/1999
EP	0843906	B1	3/2000
EP	0552050	B1	5/2000
EP	0833592	B1	5/2000
EP	0832605	B1	6/2000
EP	0830094	B1	9/2000
EP	1034747	A1	9/2000
EP	1034748	A1	9/2000
EP	0694290	B1	11/2000
EP	1050278	A1	11/2000
EP	1053719	A1	11/2000
EP	1053720	A1	11/2000
EP	1055399	A1	11/2000
EP	1055400	A1	11/2000
EP	1058177	A1	12/2000
EP	1080694	A1	3/2001
EP	1090592	A1	4/2001
EP	1095627	A1	5/2001
EP	1256318	B1	5/2001
EP	0806914	B1	9/2001
EP	0768840	B1	12/2001
EP	0908152	B1	1/2002
EP	0872213	B1	5/2002
EP	0862386	B1	6/2002
EP	0949886	B1	9/2002
EP	1238634	A2	9/2002
EP	0858295	B1	12/2002
EP	0656188	B1	1/2003
EP	0717960	B1	2/2003
EP	1284120	A1	2/2003
EP	1287788	A1	3/2003
EP	0717966	B1	4/2003
EP	0869742	B1	5/2003
EP	0829235	B1	6/2003
EP	0887046	B1	7/2003
EP	0852480	B1	8/2003
EP	0891154	B1	9/2003
EP	0813843	B1	10/2003
EP	0873089	B1	10/2003
EP	0856326	B1	11/2003
EP	1374788	A1	1/2004
EP	0741996	B1	2/2004
EP	0814712	B1	2/2004
EP	1402837	A1	3/2004
EP	0705570	B1	4/2004
EP	0959784	B1	4/2004
EP	1407719	A2	4/2004
EP	1086713	B1	5/2004
EP	0996378	B1	6/2004

(56) **References Cited**

FOREIGN PATENT DOCUMENTS

EP	1426012	A1	6/2004
EP	0833593	B2	7/2004
EP	1442694	A1	8/2004
EP	0888749	B1	9/2004
EP	0959786	B1	9/2004
EP	1459695	A1	9/2004
EP	1254636	B1	10/2004
EP	1473819	A1	11/2004
EP	1477119	A1	11/2004
EP	1479345	A1	11/2004
EP	1479347	A1	11/2004
EP	1479348	A1	11/2004
EP	0754437	B2	12/2004
EP	1025807	B1	12/2004
EP	1001710	B1	1/2005
EP	1520521	A1	4/2005
EP	1520522	A1	4/2005
EP	1520523	A1	4/2005
EP	1520525	A1	4/2005
EP	1522264	A1	4/2005
EP	1523942	A2	4/2005
EP	1550408	A1	7/2005
EP	1557129	A1	7/2005
EP	1064883	B1	8/2005
EP	1067876	B1	8/2005
EP	0870473	B1	9/2005
EP	1157666	B1	9/2005
EP	0880338	B1	10/2005
EP	1158917	B1	11/2005
EP	1344498	B1	11/2005
EP	0906764	B1	12/2005
EP	1330989	B1	12/2005
EP	0771176	B2	1/2006
EP	1621138	A2	2/2006
EP	1621139	A2	2/2006
EP	1621141	A2	2/2006
EP	1621145	A2	2/2006
EP	1621151	A2	2/2006
EP	1034746	B1	3/2006
EP	1201196	B1	3/2006
EP	1632191	A2	3/2006
EP	1647231	A1	4/2006
EP	1065981	B1	5/2006
EP	1082944	B1	5/2006
EP	1230899	B1	5/2006
EP	1652481	A2	5/2006
EP	1382303	B1	6/2006
EP	1253866	B1	7/2006
EP	1032318	B1	8/2006
EP	1045672	B1	8/2006
EP	1617768	B1	8/2006
EP	1693015	A2	8/2006
EP	1400214	B1	9/2006
EP	1702567	A2	9/2006
EP	1129665	B1	11/2006
EP	1400206	B1	11/2006
EP	1721568	A1	11/2006
EP	1256317	B1	12/2006
EP	1285633	B1	12/2006
EP	1728473	A1	12/2006
EP	1728475	A2	12/2006
EP	1736105	A1	12/2006
EP	1011494	B1	1/2007
EP	1479346	B1	1/2007
EP	1484024	B1	1/2007
EP	1749485	A1	2/2007
EP	1754445	A2	2/2007
EP	1759812	A1	3/2007
EP	1767157	A1	3/2007
EP	1767163	A1	3/2007
EP	1769756	A1	4/2007
EP	1769758	A1	4/2007
EP	1581128	B1	5/2007
EP	1780825	A1	5/2007
EP	1785097	A2	5/2007
EP	1790293	A2	5/2007
EP	1790294	A1	5/2007
EP	1563793	B1	6/2007
EP	1800610	A1	6/2007
EP	1300117	B1	8/2007
EP	1813199	A1	8/2007
EP	1813200	A2	8/2007
EP	1813201	A1	8/2007
EP	1813202	A1	8/2007
EP	1813203	A2	8/2007
EP	1813207	A1	8/2007
EP	1813209	A1	8/2007
EP	1330991	B1	9/2007
EP	1837041	A1	9/2007
EP	0922435	B1	10/2007
EP	1487359	B1	10/2007
EP	1599146	B1	10/2007
EP	1839596	A1	10/2007
EP	2110083	A2	10/2007
EP	1679096	B1	11/2007
EP	1857057	A2	11/2007
EP	1402821	B1	12/2007
EP	1872727	A1	1/2008
EP	1550410	B1	2/2008
EP	1671593	B1	2/2008
EP	1897502	A1	3/2008
EP	1611856	B1	4/2008
EP	1908417	A2	4/2008
EP	1330201	B1	6/2008
EP	1702568	B1	7/2008
EP	1943955	A2	7/2008
EP	1943957	A2	7/2008
EP	1943959	A1	7/2008
EP	1943962	A2	7/2008
EP	1943964	A1	7/2008
EP	1943976	A2	7/2008
EP	1593337	B1	8/2008
EP	1970014	A1	9/2008
EP	1980213	A2	10/2008
EP	1759645	B1	11/2008
EP	1987780	A2	11/2008
EP	1990014	A2	11/2008
EP	1552795	B1	12/2008
EP	1693008	B1	12/2008
EP	1759640	B1	12/2008
EP	1997439	A2	12/2008
EP	2000102	A2	12/2008
EP	2005894	A2	12/2008
EP	2005901	A1	12/2008
EP	2008595	A2	12/2008
EP	1736104	B1	3/2009
EP	1749486	B1	3/2009
EP	1782743	B1	3/2009
EP	2039302	A2	3/2009
EP	2039308	A2	3/2009
EP	2039316	A2	3/2009
EP	1721576	B1	4/2009
EP	1733686	B1	4/2009
EP	2044890	A1	4/2009
EP	2055243	A2	5/2009
EP	1550409	B1	6/2009
EP	1550413	B1	6/2009
EP	1719461	B1	6/2009
EP	1834594	B1	6/2009
EP	1709911	B1	7/2009
EP	2077093	A2	7/2009
EP	1745748	B1	8/2009
EP	2090231	A1	8/2009
EP	2090237	A1	8/2009
EP	2090241	A1	8/2009
EP	2090244	A2	8/2009
EP	2090245	A1	8/2009
EP	2090254	A1	8/2009
EP	2090256	A2	8/2009
EP	2095777	A2	9/2009
EP	2098170	A2	9/2009
EP	2110082	A1	10/2009
EP	2110084	A2	10/2009
EP	2111803	A2	10/2009

(56) **References Cited**

FOREIGN PATENT DOCUMENTS

EP	1762190	B8	11/2009
EP	1813208	B1	11/2009
EP	1908426	B1	11/2009
EP	2116195	A1	11/2009
EP	2116197	A2	11/2009
EP	1607050	B1	12/2009
EP	1815804	B1	12/2009
EP	1875870	B1	12/2009
EP	1878395	B1	1/2010
EP	2151204	A1	2/2010
EP	1813211	B1	3/2010
EP	2165656	A2	3/2010
EP	2165660	A2	3/2010
EP	1566150	B1	4/2010
EP	1813206	B1	4/2010
EP	1769754	B1	6/2010
EP	1854416	B1	6/2010
EP	1911408	B1	6/2010
EP	2198787	A1	6/2010
EP	1647286	B1	9/2010
EP	1825821	B1	9/2010
EP	1535565	B1	10/2010
EP	1702570	B1	10/2010
EP	1785098	B1	10/2010
EP	2005896	B1	10/2010
EP	2030578	B1	11/2010
EP	2036505	B1	11/2010
EP	2245993	A2	11/2010
EP	1627605	B1	12/2010
EP	2027811	B1	12/2010
EP	2130498	B1	12/2010
EP	2263568	A2	12/2010
EP	1994890	B1	1/2011
EP	2005900	B1	1/2011
EP	2286738	A2	2/2011
EP	1690502	B1	3/2011
EP	2292153	A1	3/2011
EP	1769755	B1	4/2011
EP	2090240	B1	4/2011
EP	2305135	A1	4/2011
EP	2314254	A2	4/2011
EP	2316345	A1	5/2011
EP	2316366	A2	5/2011
EP	1813205	B1	6/2011
EP	2090243	B1	6/2011
EP	2329773	A1	6/2011
EP	2090239	B1	7/2011
EP	2340771	A2	7/2011
EP	2353545	A1	8/2011
EP	2361562	A1	8/2011
EP	1836986	B1	11/2011
EP	1908414	B1	11/2011
EP	2153781	B1	11/2011
EP	2389928	A2	11/2011
EP	1847225	B1	12/2011
EP	2399538	A2	12/2011
EP	1785102	B1	1/2012
EP	2090253	B1	3/2012
EP	2430986	A2	3/2012
EP	2446834	A1	5/2012
EP	2455007	A2	5/2012
EP	2457519	A1	5/2012
EP	2462880	A2	6/2012
EP	1813204	B1	7/2012
EP	2189121	B1	7/2012
EP	2005895	B1	8/2012
EP	2090248	B1	8/2012
EP	2481359	A1	8/2012
EP	1935351	B1	9/2012
EP	2497431	A1	9/2012
EP	1616549	B1	10/2012
EP	2030579	B1	10/2012
EP	2090252	B1	10/2012
EP	2517637	A1	10/2012
EP	2517638	A1	10/2012
EP	2517642	A2	10/2012
EP	2517645	A2	10/2012
EP	2517649	A2	10/2012
EP	2517651	A2	10/2012
EP	1884206	B1	3/2013
EP	2090238	B1	4/2013
EP	1982657	B1	7/2013
EP	2090234	B1	9/2013
EP	2633830	A1	9/2013
EP	2644124	A1	10/2013
EP	2644209	A2	10/2013
EP	2649948	A1	10/2013
EP	2700367	A1	2/2014
EP	1772105	B1	5/2014
EP	2446835	B1	1/2015
ES	2396594	T3	2/2013
FR	459743	A	11/1913
FR	999646	A	2/1952
FR	1112936	A	3/1956
FR	2598905	A1	11/1987
FR	2765794	A	1/1999
FR	2815842		10/2000
GB	939929	A	10/1963
GB	1210522	A	10/1970
GB	1217159	A	12/1970
GB	1339394	A	12/1973
GB	2024012	A	1/1980
GB	2109241	A	6/1983
GB	2272159	A	5/1994
GB	2284242	A	5/1995
GB	2286435	A	8/1995
GB	2336214	A	10/1999
GB	2425903	A	11/2006
GR	93100110	A	11/1993
JP	50-33988	U	4/1975
JP	S 58500053	A	1/1983
JP	60-100955	A	6/1985
JP	61-98249	A	5/1986
JP	S 61502036	A	9/1986
JP	S 63-59764	A	3/1988
JP	S 63-147449	A	6/1988
JP	63-203149		8/1988
JP	H 02-279149	A	11/1990
JP	3-12126	A	1/1991
JP	H 05-084252	A	4/1993
JP	5-212039	A	8/1993
JP	6007357	A	1/1994
JP	H 6-30945	A	2/1994
JP	H 06-26812	U	4/1994
JP	H 6-121798	A	5/1994
JP	H 06-197901	A	7/1994
JP	H 06-237937	A	8/1994
JP	7-31623	A	2/1995
JP	7051273	A	2/1995
JP	7-124166	A	5/1995
JP	H 7-163574	A	6/1995
JP	07-171163		7/1995
JP	7-255735	A	10/1995
JP	H 7-285089	A	10/1995
JP	8-33642	A	2/1996
JP	8033641	A	2/1996
JP	8-164141	A	6/1996
JP	H 08-182684	A	7/1996
JP	H 08-507708	A	8/1996
JP	8229050	A	9/1996
JP	H 09-501081	A	2/1997
JP	H 09-501577	A	2/1997
JP	H 09-164144	A	6/1997
JP	H 10-118090	A	5/1998
JP	10-512469	A	12/1998
JP	2000-14632		1/2000
JP	2000033071	A	2/2000
JP	2000-112002	A	4/2000
JP	2000-166932	A	6/2000
JP	2000171730	A	6/2000
JP	2000287987	A	10/2000
JP	2000325303	A	11/2000
JP	2001-046384	A	2/2001
JP	2001-87272	A	4/2001

(56) **References Cited**

FOREIGN PATENT DOCUMENTS

JP	2001-514541	A	9/2001
JP	2001-276091	A	10/2001
JP	2001-517473	A	10/2001
JP	2001286477	A	10/2001
JP	2002-51974	A	2/2002
JP	2002-085415	A	3/2002
JP	2002143078	A	5/2002
JP	2002-528161	A	9/2002
JP	2002369820	A	12/2002
JP	2003-500153	A	1/2003
JP	2003-504104	A	2/2003
JP	2003-135473	A	5/2003
JP	2003-164066		6/2003
JP	2003-521301	A	7/2003
JP	2004-162035	A	6/2004
JP	2004-229976	A	8/2004
JP	2004-524076	A	8/2004
JP	2004-531280	A	10/2004
JP	2004-532084	A	10/2004
JP	2004-532676	A	10/2004
JP	2004-329624	A	11/2004
JP	2004-337617	A	12/2004
JP	2004-344663		12/2004
JP	2005-028147	A	2/2005
JP	2005-28148	A	2/2005
JP	2005-028149	A	2/2005
JP	2005-505309	A	2/2005
JP	2005505322	T	2/2005
JP	2005-103280	A	4/2005
JP	2005-103281	A	4/2005
JP	2005-511131	A	4/2005
JP	2005103293	A	4/2005
JP	2005131163	A	5/2005
JP	2005131164	A	5/2005
JP	2005131173	A	5/2005
JP	2005131211	A	5/2005
JP	2005131212	A	5/2005
JP	2005-137919	A	6/2005
JP	2005-144183	A	6/2005
JP	2005-516714	A	6/2005
JP	2005137423	A	6/2005
JP	2005152416	A	6/2005
JP	2005-521109	A	7/2005
JP	2005-523105	A	8/2005
JP	4461008	B2	8/2005
JP	2005524474	A	8/2005
JP	2005-296412	A	10/2005
JP	2005-328882	A	12/2005
JP	2005-335432	A	12/2005
JP	2005-342267	A	12/2005
JP	2006-034975	A	2/2006
JP	2006-34977	A	2/2006
JP	2006-034978	A	2/2006
JP	2006-034980	A	2/2006
JP	2006-506106	A	2/2006
JP	2006-187649	A	7/2006
JP	2006-218297	A	8/2006
JP	2006-223872	A	8/2006
JP	2006-281405	A	10/2006
JP	2006-334417	A	12/2006
JP	2006-346445	A	12/2006
JP	2007-61628	A	3/2007
JP	2007-098130	A	4/2007
JP	2007-105481	A	4/2007
JP	3906843	B2	4/2007
JP	2007-117725	A	5/2007
JP	2007-130471	A	5/2007
JP	2007-222615	A	6/2007
JP	2007-203051	A	8/2007
JP	2007-203057	A	8/2007
JP	2007-524435	A	8/2007
JP	2007-229448	A	9/2007
JP	4001860	B2	10/2007
JP	2007-325922	A	12/2007
JP	2008-68073	A	3/2008
JP	2008-206967	A	9/2008
JP	2008-212637	A	9/2008
JP	2008-212638	A	9/2008
JP	2008-259860	A	10/2008
JP	2008-264535	A	11/2008
JP	2008-283459	A	11/2008
JP	2009-502351	A	1/2009
JP	2009-506799	A	2/2009
JP	2009-72599	A	4/2009
JP	2009-090113	A	4/2009
JP	2009-106752	A	5/2009
JP	2009-189836	A	8/2009
JP	2009-189838	A	8/2009
JP	2009-539420	A	11/2009
JP	2010-098844	A	4/2010
JP	4549018	B2	9/2010
JP	4783373	B2	7/2011
JP	5140421	B2	2/2013
JP	5162595	B2	3/2013
JP	2013-128791	A	7/2013
JP	5333899	B2	11/2013
RU	2008830	C1	3/1994
RU	2052979	C1	1/1996
RU	2098025	C1	12/1997
RU	2141279	C1	11/1999
RU	2144791	C1	1/2000
RU	2181566	C2	4/2002
RU	2187249	C2	8/2002
RU	2189091	C2	9/2002
RU	32984	U1	10/2003
RU	2225170	C2	3/2004
RU	42750	U1	12/2004
RU	61114	U1	2/2007
SU	189517	A	1/1967
SU	328636	A	9/1972
SU	674747	A1	7/1979
SU	886900	A1	12/1981
SU	1009439	A	4/1983
SU	1022703	A1	6/1983
SU	1333319	A2	8/1987
SU	1377053	A1	2/1988
SU	1509051	A1	9/1989
SU	1561964	A1	5/1990
SU	1708312	A1	1/1992
SU	1722476	A1	3/1992
SU	1752361	A1	8/1992
SU	1814161	A1	5/1993
WO	WO 82/02824	A1	9/1982
WO	WO 86/02254	A1	4/1986
WO	WO 91/15157	A1	10/1991
WO	WO 92/20295	A1	11/1992
WO	WO 92/21300	A1	12/1992
WO	WO 93/08755	A1	5/1993
WO	WO 93/13718	A1	7/1993
WO	WO 93/14690	A1	8/1993
WO	WO 93/15648	A1	8/1993
WO	WO 93/15850	A1	8/1993
WO	WO 93/19681	A1	10/1993
WO	WO 94/00060	A1	1/1994
WO	WO 94/11057	A1	5/1994
WO	WO 94/12108	A1	6/1994
WO	WO 94/18893	A1	9/1994
WO	WO 94/20030	A1	9/1994
WO	WO 94/22378	A1	10/1994
WO	WO 94/23659	A1	10/1994
WO	WO 94/24943	A1	11/1994
WO	WO 94/24947	A1	11/1994
WO	WO 95/02369	A1	1/1995
WO	WO 95/03743	A1	2/1995
WO	WO 95/06817	A1	3/1995
WO	WO 95/09576	A1	4/1995
WO	WO 95/09577	A1	4/1995
WO	WO 95/14436	A1	6/1995
WO	WO 95/17855	A1	7/1995
WO	WO 95/18383	A1	7/1995
WO	WO 95/18572	A1	7/1995
WO	WO 95/19739	A1	7/1995
WO	WO 95/20360	A1	8/1995
WO	WO 95/23557	A1	9/1995

(56) **References Cited**

FOREIGN PATENT DOCUMENTS

WO	WO 95/24865	A1	9/1995
WO	WO 95/25471	A3	9/1995
WO	WO 95/26562	A1	10/1995
WO	WO 95/29639	A1	11/1995
WO	WO 96/04858	A1	2/1996
WO	WO 96/18344	A2	6/1996
WO	WO 96/19151	A1	6/1996
WO	WO 96/19152	A1	6/1996
WO	WO 96/20652	A1	7/1996
WO	WO 96/21119	A1	7/1996
WO	WO 96/22055	A1	7/1996
WO	WO 96/23448	A1	8/1996
WO	WO 96/24301	A1	8/1996
WO	WO 96/27337	A1	9/1996
WO	WO 96/31155	A1	10/1996
WO	WO 96/35464	A1	11/1996
WO	WO 96/39085	A1	12/1996
WO	WO 96/39086	A1	12/1996
WO	WO 96/39087	A1	12/1996
WO	WO 96/39088	A1	12/1996
WO	WO 96/39089	A1	12/1996
WO	WO 97/00646	A1	1/1997
WO	WO 97/00647	A1	1/1997
WO	WO 97/01989	A1	1/1997
WO	WO 97/06582	A1	2/1997
WO	WO 97/10763	A1	3/1997
WO	WO 97/10764	A1	3/1997
WO	WO 97/11648	A2	4/1997
WO	WO 97/11649	A1	4/1997
WO	WO 97/15237	A1	5/1997
WO	WO 97/24073	A1	7/1997
WO	WO 97/24993	A1	7/1997
WO	WO 97/30644	A1	8/1997
WO	WO 97/34533	A1	9/1997
WO	WO 97/37598	A1	10/1997
WO	WO 97/39688	A2	10/1997
WO	WO 98/01080	A1	1/1998
WO	WO 98/17180	A1	4/1998
WO	WO 98/27880	A1	7/1998
WO	WO 98/30153	A1	7/1998
WO	WO 98/47436	A1	10/1998
WO	WO 98/58589		12/1998
WO	WO 99/03407	A1	1/1999
WO	WO 99/03408	A1	1/1999
WO	WO 99/03409	A1	1/1999
WO	WO 99/12483	A1	3/1999
WO	WO 99/12487	A1	3/1999
WO	WO 99/12488	A1	3/1999
WO	WO 99/15086	A1	4/1999
WO	WO 99/15091	A1	4/1999
WO	WO 99/23933	A2	5/1999
WO	WO 99/23959	A1	5/1999
WO	WO 99/25261	A1	5/1999
WO	WO 99/29244	A1	6/1999
WO	WO 99/34744	A1	7/1999
WO	WO 99/45849	A1	9/1999
WO	WO 99/48430	A1	9/1999
WO	WO 99/51158	A1	10/1999
WO	WO 00/24322	A1	5/2000
WO	WO 00/24330	A1	5/2000
WO	WO 00/41638	A1	7/2000
WO	WO 00/48506	A1	8/2000
WO	WO 00/53112	A2	9/2000
WO	WO 00/54653	A1	9/2000
WO	WO 00/57796	A1	10/2000
WO	WO 00/64365	A1	11/2000
WO	WO 00/72762	A1	12/2000
WO	WO 00/72765	A1	12/2000
WO	WO 01/03587	A1	1/2001
WO	WO 01/05702	A1	1/2001
WO	WO 01/10482	A1	2/2001
WO	WO 01/35845	A1	5/2001
WO	WO 01/54594	A1	8/2001
WO	WO 01/58371	A1	8/2001
WO	WO 01/62158	A2	8/2001
WO	WO 01/62161	A1	8/2001
WO	WO 01/62162	A1	8/2001
WO	WO 01/62164	A2	8/2001
WO	WO 01/62169	A2	8/2001
WO	WO 01/78605	A2	10/2001
WO	WO 01/80757	A2	11/2001
WO	WO 01/91646	A1	12/2001
WO	WO 02/00121	A1	1/2002
WO	WO 02/07608	A2	1/2002
WO	WO 02/07618	A1	1/2002
WO	WO 02/17799	A1	3/2002
WO	WO 02/19920	A1	3/2002
WO	WO 02/19932	A1	3/2002
WO	WO 02/26143	A1	4/2002
WO	WO 02/30297	A2	4/2002
WO	WO 02/32322	A2	4/2002
WO	WO 02/36028	A1	5/2002
WO	WO 02/43571	A2	6/2002
WO	WO 02/058568	A1	8/2002
WO	WO 02/060328	A1	8/2002
WO	WO 02/067785	A2	9/2002
WO	WO 02/085218	A2	10/2002
WO	WO 02/087586	A1	11/2002
WO	WO 02/098302	A1	12/2002
WO	WO 03/000138	A2	1/2003
WO	WO 03/001329	A2	1/2003
WO	WO 03/001986	A2	1/2003
WO	WO 03/013363	A1	2/2003
WO	WO 03/013372	A2	2/2003
WO	WO 03/015604	A2	2/2003
WO	WO 03/020106	A2	3/2003
WO	WO 03/020139	A2	3/2003
WO	WO 03/024339	A1	3/2003
WO	WO 03/079909	A3	3/2003
WO	WO 03/030743	A2	4/2003
WO	WO 03/037193	A1	5/2003
WO	WO 03/047436	A3	6/2003
WO	WO 03/055402	A1	7/2003
WO	WO 03/057048	A1	7/2003
WO	WO 03/057058	A1	7/2003
WO	WO 03/063694	A1	8/2003
WO	WO 03/077769	A1	9/2003
WO	WO 03/079911	A1	10/2003
WO	WO 03/082126	A1	10/2003
WO	WO 03/086206	A1	10/2003
WO	WO 03/088845	A2	10/2003
WO	WO 03/090630	A2	11/2003
WO	WO 03/094743	A1	11/2003
WO	WO 03/094745	A1	11/2003
WO	WO 03/094746	A1	11/2003
WO	WO 03/094747	A1	11/2003
WO	WO 03/101313	A1	12/2003
WO	WO 03/105698	A2	12/2003
WO	WO 03/105702	A2	12/2003
WO	WO 2004/006980	A2	1/2004
WO	WO 2004/011037	A2	2/2004
WO	WO 2004/019769	A1	3/2004
WO	WO 2004/019803	A1	3/2004
WO	WO 2004/021868	A2	3/2004
WO	WO 2004/028585	A2	4/2004
WO	WO 2004/030554	A1	4/2004
WO	WO 2004/032754	A2	4/2004
WO	WO 2004/032760	A2	4/2004
WO	WO 2004/032762	A1	4/2004
WO	WO 2004/032763	A2	4/2004
WO	WO 2004/032783	A1	4/2004
WO	WO 2004/034875	A2	4/2004
WO	WO 2004/047626	A1	6/2004
WO	WO 2004/047653	A2	6/2004
WO	WO 2004/049956	A2	6/2004
WO	WO 2004/052426	A2	6/2004
WO	WO 2004/056276	A1	7/2004
WO	WO 2004/056277	A1	7/2004
WO	WO 2004/062516	A1	7/2004
WO	WO 2004/064600	A2	8/2004
WO	WO 2004/078050	A2	9/2004
WO	WO 2004/078051	A2	9/2004
WO	WO 2004/078236	A2	9/2004
WO	WO 2004/086987	A1	10/2004

(56) **References Cited**

FOREIGN PATENT DOCUMENTS

WO	WO 2004/096015	A2	11/2004
WO	WO 2004/096057	A2	11/2004
WO	WO 2004/103157	A2	12/2004
WO	WO 2004/105593	A1	12/2004
WO	WO 2004/105621	A1	12/2004
WO	WO 2004/112618	A2	12/2004
WO	WO 2004/112652	A2	12/2004
WO	WO 2005/027983	A2	3/2005
WO	WO 2005/037329	A2	4/2005
WO	WO 2005/042041	A1	5/2005
WO	WO 2005/044078	A2	5/2005
WO	WO 2005/055846	A1	6/2005
WO	WO 2005/072634	A2	8/2005
WO	WO 2005/078892	A1	8/2005
WO	WO 2005/079675	A2	9/2005
WO	WO 2005/096954	A2	10/2005
WO	WO 2005/112806	A2	12/2005
WO	WO 2005/112808	A1	12/2005
WO	WO 2005/115251	A1	12/2005
WO	WO 2005/115253	A2	12/2005
WO	WO 2005/117735	A1	12/2005
WO	WO 2005/122936	A1	12/2005
WO	WO 2006/023486	A1	3/2006
WO	WO 2006/023578	A2	3/2006
WO	WO 2006/027014	A1	3/2006
WO	WO 2006/028314	A1	3/2006
WO	WO 2006/044490	A2	4/2006
WO	WO 2006/044581	A2	4/2006
WO	WO 2006/044810	A2	4/2006
WO	WO 2006/051252	A1	5/2006
WO	WO 2006/059067	A1	6/2006
WO	WO 2006/083748	A1	8/2006
WO	WO 2006/085389	A1	8/2006
WO	WO 2006/092563	A1	9/2006
WO	WO 2006/092565	A1	9/2006
WO	WO 2006/115958	A1	11/2006
WO	WO 2006/125940	A1	11/2006
WO	WO 2006/132992	A2	12/2006
WO	WO 2007/002180	A2	1/2007
WO	WO 2007/016290	A2	2/2007
WO	WO 2007/018898	A2	2/2007
WO	WO 2007/089603	A2	8/2007
WO	WO 2007/098220	A2	8/2007
WO	WO 2007/121579	A1	11/2007
WO	WO 2007/131110	A2	11/2007
WO	WO 2007/137304	A2	11/2007
WO	WO 2007/139734	A2	12/2007
WO	WO 2007/142625	A2	12/2007
WO	WO 2007/145825	A2	12/2007
WO	WO 2007/146987	A2	12/2007
WO	WO 2007/147439	A1	12/2007
WO	WO 2008/020964	A2	2/2008
WO	WO 2008/021969	A2	2/2008
WO	WO 2008/039249	A1	4/2008
WO	WO 2008/039270	A1	4/2008
WO	WO 2008/045383	A2	4/2008
WO	WO 2008/057281	A2	5/2008
WO	WO 2008/070763	A1	6/2008
WO	WO 2008/089404	A2	7/2008
WO	WO 2008/101080	A1	8/2008
WO	WO 2008/101228	A2	8/2008
WO	WO 2008/109125	A1	9/2008
WO	WO 2008/124748	A1	10/2008
WO	WO 2009/022614	A1	2/2009
WO	WO 2009/023851	A1	2/2009
WO	WO 2009/033057	A2	3/2009
WO	WO 2009/039506	A1	3/2009
WO	WO 2009/046394	A1	4/2009
WO	WO 2009/067649	A2	5/2009
WO	WO 2009/091497	A2	7/2009
WO	WO 2009/137761	A2	11/2009
WO	WO 2009/143092	A1	11/2009
WO	WO 2009/143331	A1	11/2009
WO	WO 2009/150650	A2	12/2009
WO	WO 2010/028332	A2	3/2010
WO	WO 2010/030434	A1	3/2010
WO	WO 2010/050771	A2	5/2010
WO	WO 2010/054404	A1	5/2010
WO	WO 2010/063795	A1	6/2010
WO	WO 2010/098871	A2	9/2010
WO	WO 2011/008672	A2	1/2011
WO	WO 2011/044343	A2	4/2011
WO	WO 2011/060311	A2	5/2011
WO	WO 2012/006306	A2	1/2012
WO	WO 2012/021671	A1	2/2012
WO	WO 2012/040438	A1	3/2012
WO	WO 2012/044551	A1	4/2012
WO	WO 2012/044554	A1	4/2012
WO	WO 2012/044606	A2	4/2012
WO	WO 2012/044820	A1	4/2012
WO	WO 2012/044844	A2	4/2012
WO	WO 2012/044853	A1	4/2012
WO	WO 2012/058213	A2	5/2012
WO	WO 2012/068156	A2	5/2012
WO	WO 2012/148667	A2	11/2012
WO	WO 2012/148703	A2	11/2012
WO	WO 2013/043707	A2	3/2013
WO	WO 2013/043717	A1	3/2013

OTHER PUBLICATIONS

ASTM procedure D2240-05, "Standard Test Method for Rubber Property-Durometer Hardness," (Published Apr. 2010).
Miyata et al., "Biomolecule-Sensitive Hydrogels," Advanced Drug Delivery Reviews, 54 (2002) pp. 79-98.
Jeong et al., "Thermosensitive Sol-Gel Reversible Hydrogels," Advanced Drug Delivery Reviews, 54 (2002) pp. 37-51.
Byrne et al., "Molecular Imprinting Within Hydrogels," Advanced Drug Delivery Reviews, 54 (2002) pp. 149-161.
Qiu et al., "Environment-Sensitive Hydrogels for Drug Delivery," Advanced Drug Delivery Reviews, 53 (2001) pp. 321-339.
Hoffman, "Hydrogels for Biomedical Applications," Advanced Drug Delivery Reviews, 43 (2002) pp. 3-12.
Hoffman, "Hydrogels for Biomedical Applications," Advanced Drug Delivery Reviews, 54 (2002) pp. 3-12.
Peppas, "Physiologically Responsive Hydrogels," Journal of Bioactive and Compatible Polymers, vol. 6 (Jul. 1991) pp. 241-246.
Ebara, "Carbohydrate-Derived Hydrogels and Microgels," Engineered Carbohydrate-Based Materials for Biomedical Applications: Polymers, Surfaes, Dendrimers, Nanoparticles, and Hydrogels, Edited by Ravin Narain, 2011, pp. 337-345.
Peppas, Editor "Hydrogels in Medicine and Pharmacy," vol. I, Fundamentals, CRC Press, 1986.
U.S. Appl. No. 13/763,054, filed Feb. 8, 2013.
International Search Report for PCT/US2011/053542, dated Jan. 18, 2012 (6 pages).
Written Opinion for PCT/US2011/053542, dated Jan. 18, 2012 (8 pages).
Partial European Search Report for 13161457.0, dated Jul. 31, 2013 (6 pages).
European Search Report for 13161481.0, dated Jul. 30, 2013 (9 pages).
European Search Report for 13161485.1, dated Jul. 26, 2013 (7 pages).
European Search Report for 13161397.8, dated Jul. 29, 2013 (5 pages).
Partial European Search Report for 13161459.6, dated Aug. 1, 2013 (11 pages).
Partial European Search Report for 13161352.3, dated Jul. 29, 2013 (9 pages).
European Search Report for 13161352.3, dated Nov. 18, 2013 (12 pages).
European Search Report for 13161457.0, dated Nov. 18, 2013 (10 pages).
European Search Report for 12166178.9, dated Oct. 17, 2013 (8 pages).
European Search Report for 13161472.9, dated Sep. 23, 2013 (5 pages).
European Search Report for 13161450.5, dated Sep. 25, 2013 (8 pages).

(56) **References Cited**

OTHER PUBLICATIONS

European Search Report for 13161431.5, dated Sep. 30, 2013 (7 pages).
European Search Report for 13161438.0, dated Sep. 5, 2013 (8 pages).
International Search Report for PCT/US2013/046513, dated Nov. 6, 2013 (6 pages).
International Search Report for PCT/US2013/046500, dated Nov. 6, 2013 (6 pages).
International Search Report for PCT/US2013/034019, dated Nov. 19, 2013 (9 pages).
Written Opinion for PCT/US2013/034019, dated Nov. 19, 2013 (10 pages).
International Search Report for PCT/US2013/034021, dated Jul. 31, 2013 (4 pages).
Written Opinion for PCT/US2013/034004, dated Jul. 26, 2013 (8 pages).
International Search Report for PCT/U52013/034004, dated Jul. 26, 2013 (4 pages).
International Search Report for PCT/US2013/034011, dated Sep. 5, 2013 (6 pages).
International Search Report for PCT/US2013/034008, dated Dec. 6, 2013 (6 pages).
Written Opinion for PCT/US2013/034008, dated Dec. 6, 2013 (6 pages).
International Search Report for PCT/US2013/034002, dated Sep. 27, 2013 (7 pages).
International Search Report for PCT/US2013/033999, dated Sep. 20, 2013 (10 pages).
Written Opinion for PCT/US2013/033999, dated Sep. 20, 2013 (15 pages).
International Search Report for PCT/US2013/033997, dated Sep. 20, 2013 (8 pages).
Written Opinion for PCT/US2013/033997, dated Sep. 20, 2013 (8 pages).
International Search Report for PCT/US2013/046525, dated Nov. 6, 2013 (6 pages).
Written Opinion for PCT/US2013/046525, dated Nov. 6, 2013 (8 pages).
International Search Report for PCT/US2013/046516, dated Nov. 6, 2013 (6 pages).
Written Opinion for PCT/US2013/046516, dated Nov. 6, 2013 (8 pages).
International Search Report for PCT/US2013/034048, dated Jan. 14, 2014 (10 pages).
Written Opinion for PCT/US2013/034048, dated Jan. 14, 2014 (12 pages).
International Search Report for PCT/US2013/034040, dated Sep. 17, 2013 (7 pages).
International Search Report for PCT/US2013/034025, dated Dec. 3, 2013 (9 pages).
Written Opinion for PCT/US2013/034025, dated Dec. 3, 2013 (8 pages).
International Search Report for PCT/US2012/032976, dated Oct. 17, 2013 (7 pages).
International Preliminary Report on Patentability for PCT/US2012/032976, dated Oct. 29, 2013 (9 pages).
International Preliminary Report on Patentability for PCT/US2011/053542, dated Apr. 2, 2013 (8 pages).
European Search Report for 13161459.6, dated Nov. 28, 2013 (15 pages).
Matsuda, "Thermodynamics of Formation of Porous Polymeric Membrane from Solutions," Polymer Journal, vol. 23, No. 5, pp. 435-444 (1991).
Young, "Microcellular foams via phase separation," Journal of Vacuum Science & Technology A 4(3), (May/Jun. 1986).
U.S. Appl. No. 14/540,731, filed Nov. 13, 2014.
U.S. Appl. No. 14/540,779, filed Nov. 13, 2014.
U.S. Appl. No. 14/540,807, filed Nov. 13, 2014.
U.S. Appl. No. 14/549,098, filed Nov. 20, 2014.
U.S. Appl. No. 14/549,219, filed Nov. 20, 2014.
U.S. Appl. No. 14/518,652, filed Oct. 20, 2014.
U.S. Appl. No. 14/578,909, filed Dec. 22, 2014.
Disclosed Anonymously, "Motor-Driven Surgical Stapler Improvements," Research Disclosure Database No. 526041, Published: Feb. 2008.
C.C. Thompson et al., "Peroral Endoscopic Reduction of Dilated Gastrojejunal Anastomosis After Roux-en-Y Gastric Bypass: A Possible New Option for Patients with Weight Regain," Surg Endosc (2006) vol. 20, pp. 1744-1748.
B.R. Coolman, DVM, MS et al., "Comparison of Skin Staples With Sutures for Anastomosis of the Small Intestine in Dogs," Abstract; http://www.blackwell-synergy.com/doi/abs/10.1053/jvet.2000.7539?cookieSet=1&journalCode=vsu which redirects to http://www3.interscience.wiley.com/journal/119040681/abstract?CRETRY=1&SRETRY=0; [online] accessed: Sep. 22, 2008 (2 pages).
The Sodem Aseptic Battery Transfer Kit, Sodem Systems, (2000), 3 pages.
"Biomedical Coatings," Fort Wayne Metals, Research Products Corporation, obtained online at www.fwmetals.com on Jun. 21, 2010 (1 page).
Van Meer et al., "A Disposable Plastic Compact Wrist for Smart Minimally Invasive Surgical Tools," LAAS/CNRS (Aug. 2005).
Breedveld et al., "A New, Easily Miniaturized Sterrable Endoscope," IEEE Engineering in Medicine and Biology Magazine (Nov./Dec. 2005).
D. Tuite, Ed., "Get the Lowdown on Ultracapacitors," Nov. 15, 2007; [online] URL: http://electronicdesign.com/Articles/Print.cfm?ArticleID=17465, accessed Jan. 15, 2008 (5 pages).
Datasheet for Panasonic TK Relays Ultra Low Profile 2 A Polarized Relay, Copyright Matsushita Electric Works, Ltd. (Known of at least as early as Aug. 17, 2010), 5 pages.
Covidien Brochure, "Endo GIA™ Reloads with Tri-Staple™ Technology," (2010), 1 page.
Covidien Brochure, "Endo GIA™ Reloads with Tri-Staple™ Technology and Endo GIA™ Ultra Universal Staplers," (2010), 2 pages.
Covidien Brochure, "Endo GIA™ Black Reload with Tri-Staple™ Technology," (2012), 2 pages.
Covidien Brochure, "Endo GIA™ Curved Tip Reload with Tri-Staple™ Technology," (2012), 2 pages.
Covidien Brochure, "Endo GIA™ Reloads with Tri-Staple™ Technology," (2010), 2 pages.
Covidien Brochure, "Endo GIA™ Ultra Universal Stapler," (2010), 2 pages.
Chen et al., "Elastomeric Biomaterials for Tissue Engineering," Progress in Polymer Science 38 (2013), pp. 584-671.
Pitt et al., "Attachment of Hyaluronan to Metallic Surfaces," J. Biomed. Mater. Res. 68A: pp. 95-106, 2004.
Schellhammer et al., "Poly-Lactic-Acid for Coating of Endovascular Stents: Preliminary Results in Canine Experimental Av-Fistulae," Mat.-wiss. u. Werkstofftech., 32, pp. 193-199 (2001).
Solorio et al., "Gelatin Microspheres Crosslinked with Genipin for Local Delivery of Growth Factors," J. Tissue Eng. Regen. Med. (2010), 4(7): pp. 514-523.
U.S. Appl. No. 14/498,070, filed Sep. 26, 2014.
U.S. Appl. No. 14/498,087, filed Sep. 26, 2014.
U.S. Appl. No. 14/498,105, filed Sep. 26, 2014.
U.S. Appl. No. 14/498,107, filed Sep. 26, 2014.
U.S. Appl. No. 14/498,121, filed Sep. 26, 2014.
U.S. Appl. No. 14/498,145, filed Sep. 26, 2014.
U.S. Appl. No. 14/318,996, filed Jun. 30, 2014.
U.S. Appl. No. 14/319,006, filed Jun. 30, 2014.
U.S. Appl. No. 14/319,014, filed Jun. 30, 2014.
U.S. Appl. No. 14/318,991, filed Jun. 30, 2014.
U.S. Appl. No. 14/319,004, filed Jun. 30, 2014.
U.S. Appl. No. 14/319,008, filed Jun. 30, 2014.
U.S. Appl. No. 14/318,997, filed Jun. 30, 2014.
U.S. Appl. No. 14/319,002, filed Jun. 30, 2014.
U.S. Appl. No. 14/319,013, filed Jun. 30, 2014.
U.S. Appl. No. 14/319,016, filed Jun. 30, 2014.
U.S. Appl. No. 13/974,166, filed Aug. 23, 2013.
U.S. Appl. No. 14/138,481, filed Dec. 23, 2013.

(56) **References Cited**

OTHER PUBLICATIONS

U.S. Appl. No. 13/974,215, filed Aug. 23, 2013.
U.S. Appl. No. 13/974,202, filed Aug. 23, 2013.
U.S. Appl. No. 13/974,205, filed Aug. 23, 2013.
U.S. Appl. No. 13/974,224, filed Aug. 23, 2013.
U.S. Appl. No. 13/974,169, filed Aug. 23, 2013.
U.S. Appl. No. 13/974,206, filed Aug. 23, 2013.
U.S. Appl. No. 13/974,227, filed Aug. 23, 2013.
U.S. Appl. No. 13/974,174, filed Aug. 23, 2013.
U.S. Appl. No. 13/974,177, filed Aug. 23, 2013.
U.S. Appl. No. 13/974,182, filed Aug. 23, 2013.
U.S. Appl. No. 13/974,208, filed Aug. 23, 2013.
U.S. Appl. No. 13/974,209, filed Aug. 23, 2013.
U.S. Appl. No. 14/559,172, filed Dec. 3, 2014.
U.S. Appl. No. 14/559,188, filed Dec. 3, 2014.
U.S. Appl. No. 14/559,224, filed Dec. 3, 2014.
U.S. Appl. No. 14/559,251, filed Dec. 3, 2014.
U.S. Appl. No. 14/595,645, filed Jan. 13, 2015.
U.S. Appl. No. 12/031,573, filed Feb. 14, 2008.
U.S. Appl. No. 14/187,383, filed Feb. 24, 2014.
U.S. Appl. No. 14/187,386, filed Feb. 24, 2014.
U.S. Appl. No. 14/187,390, filed Feb. 24, 2014.
U.S. Appl. No. 14/187,385, filed Feb. 24, 2014.
U.S. Appl. No. 14/187,384, filed Feb. 24, 2014.
U.S. Appl. No. 14/187,389, filed Feb. 24, 2014.
U.S. Appl. No. 14/226,142, filed Mar. 26, 2014.
U.S. Appl. No. 14/226,106, filed Mar. 26, 2014.
U.S. Appl. No. 14/226,099, filed Mar. 26, 2014.
U.S. Appl. No. 14/226,094, filed Mar. 26, 2014.
U.S. Appl. No. 14/226,117, filed Mar. 26, 2014.
U.S. Appl. No. 14/226,075, filed Mar. 26, 2014.
U.S. Appl. No. 14/226,093, filed Mar. 26, 2014.
U.S. Appl. No. 14/226,116, filed Mar. 26, 2014.
U.S. Appl. No. 14/226,071, filed Mar. 26, 2014.
U.S. Appl. No. 14/226,097, filed Mar. 26, 2014.
U.S. Appl. No. 14/226,126, filed Mar. 26, 2014.
U.S. Appl. No. 14/226,133, filed Mar. 26, 2014.
U.S. Appl. No. 14/226,081, filed Mar. 26, 2014.
U.S. Appl. No. 14/226,076, filed Mar. 26, 2014.
U.S. Appl. No. 14/226,111, filed Mar. 26, 2014.
U.S. Appl. No. 14/226,125, filed Mar. 26, 2014.

* cited by examiner

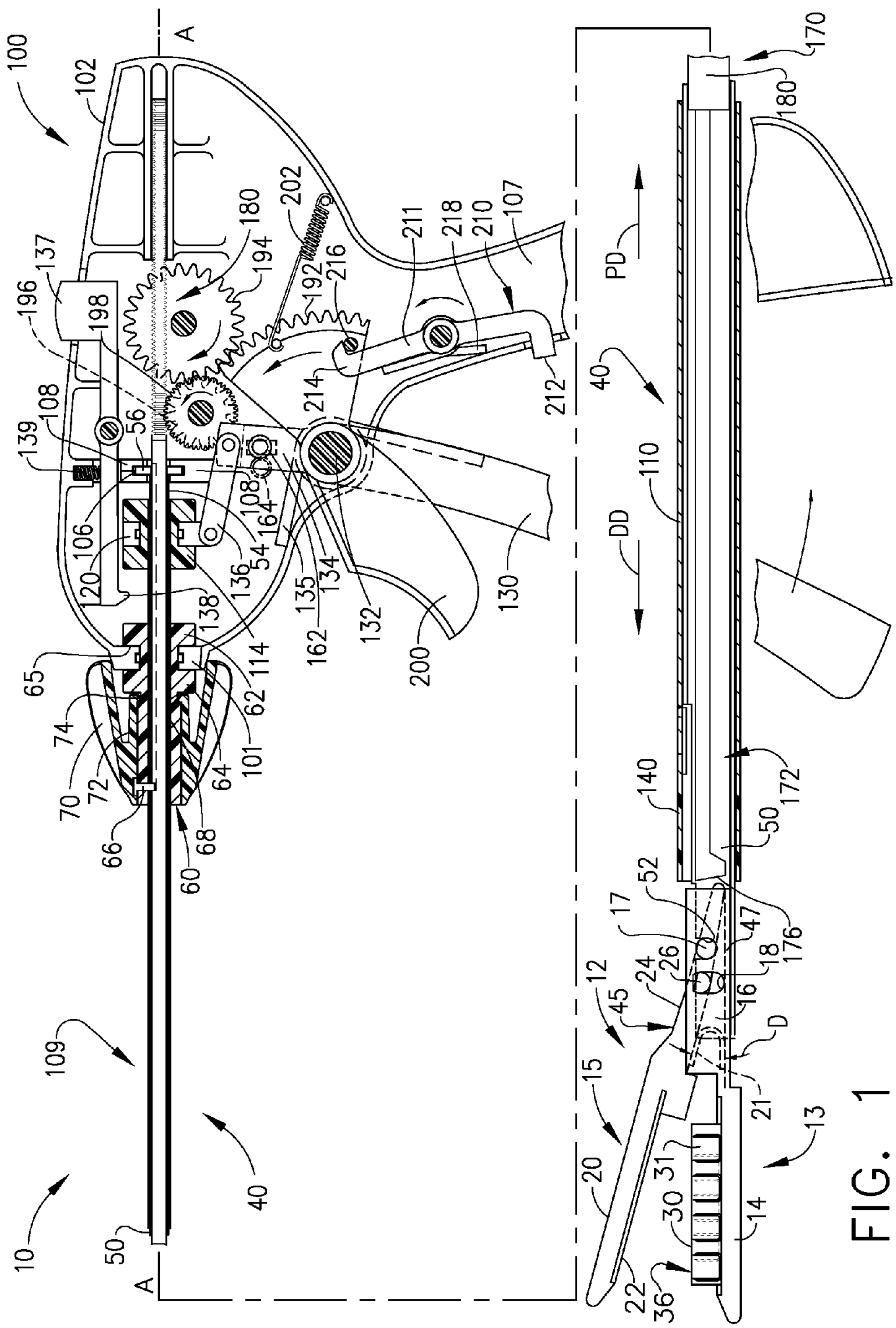


FIG. 1

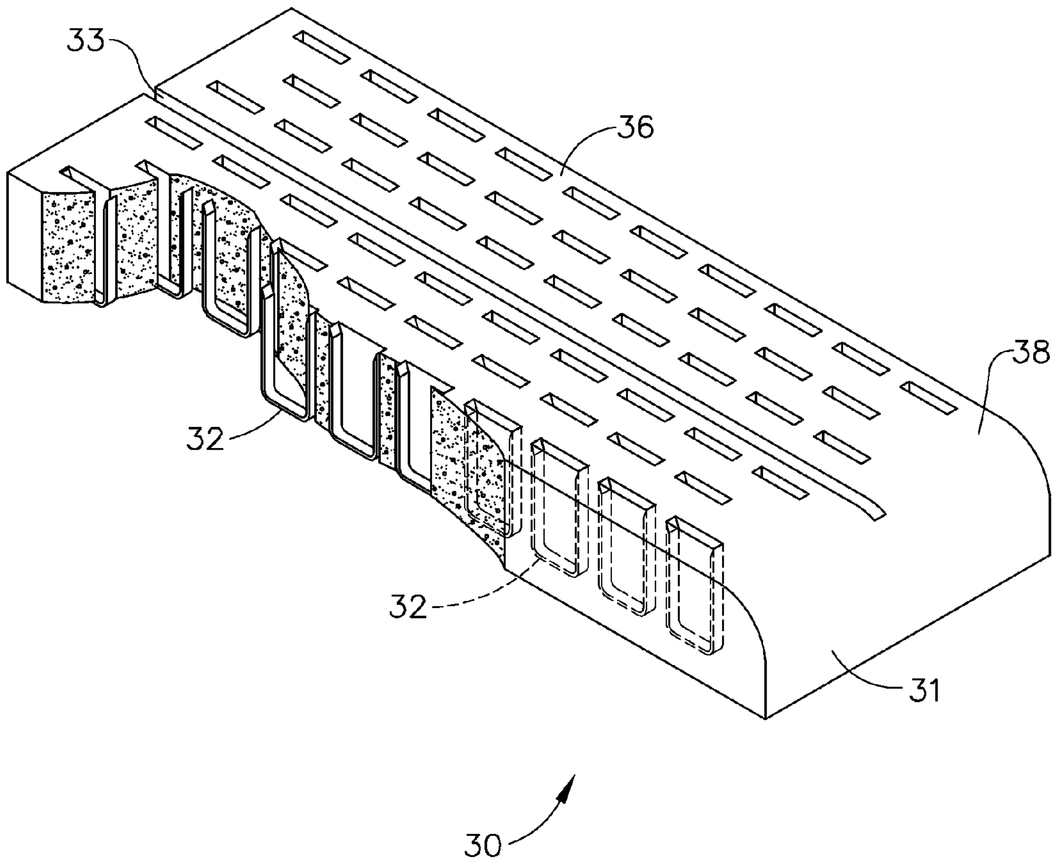


FIG. 1A

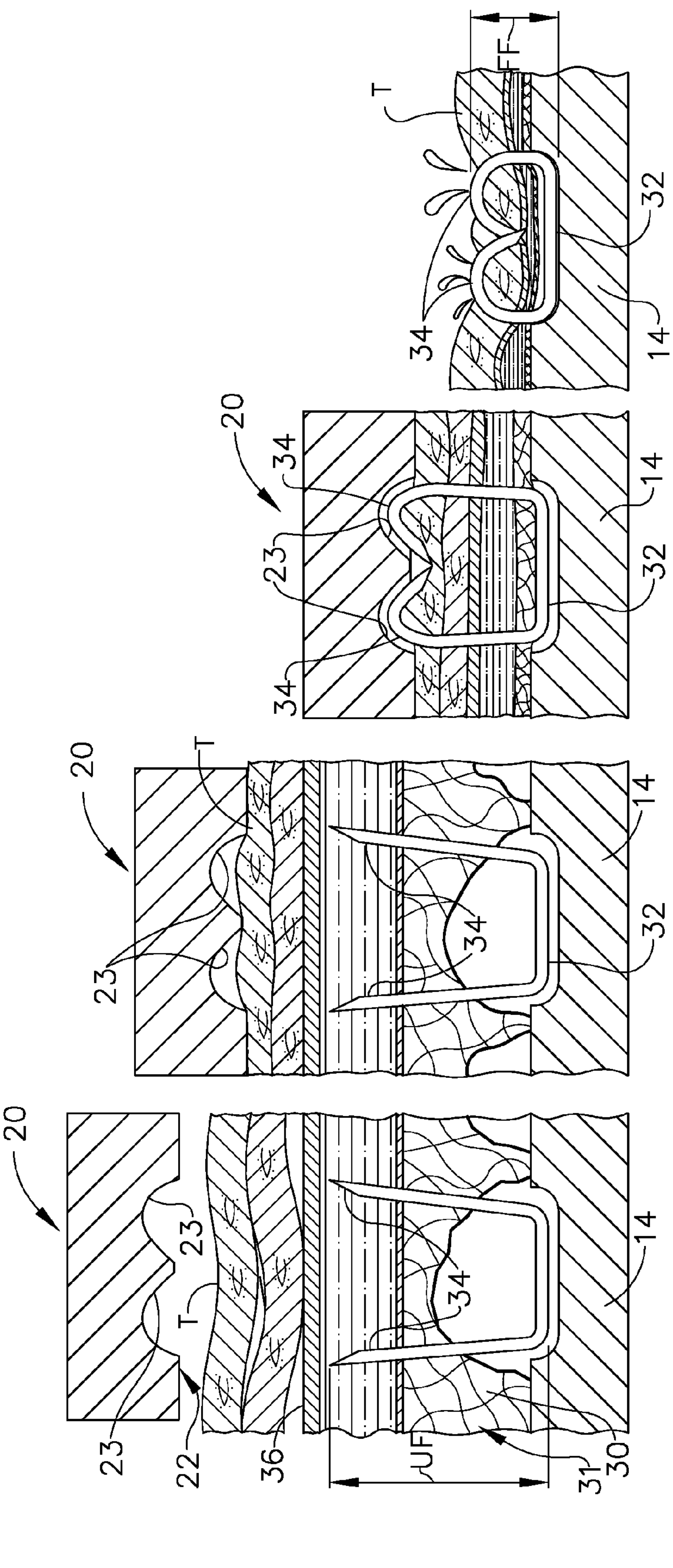


FIG. 1B

FIG. 1C

FIG. 1D

FIG. 1E

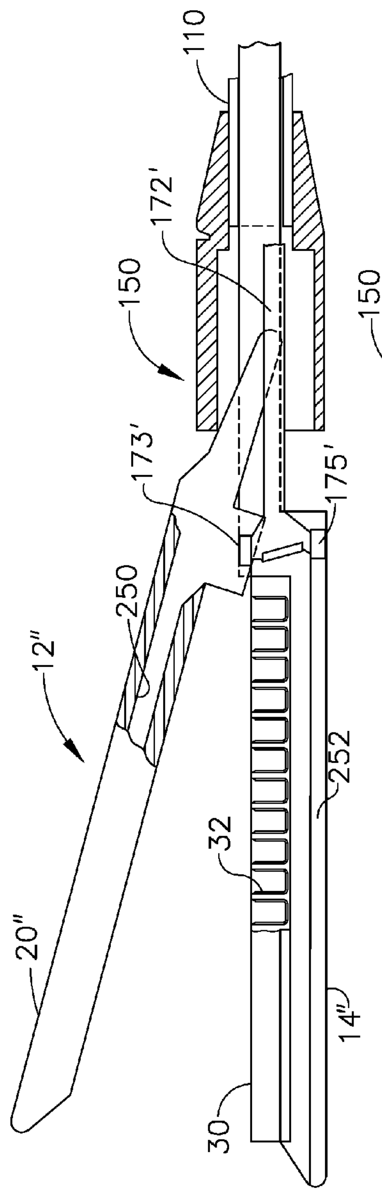


FIG. 2

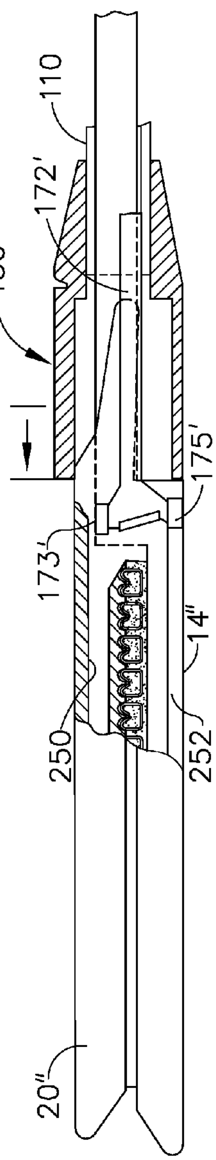


FIG. 3

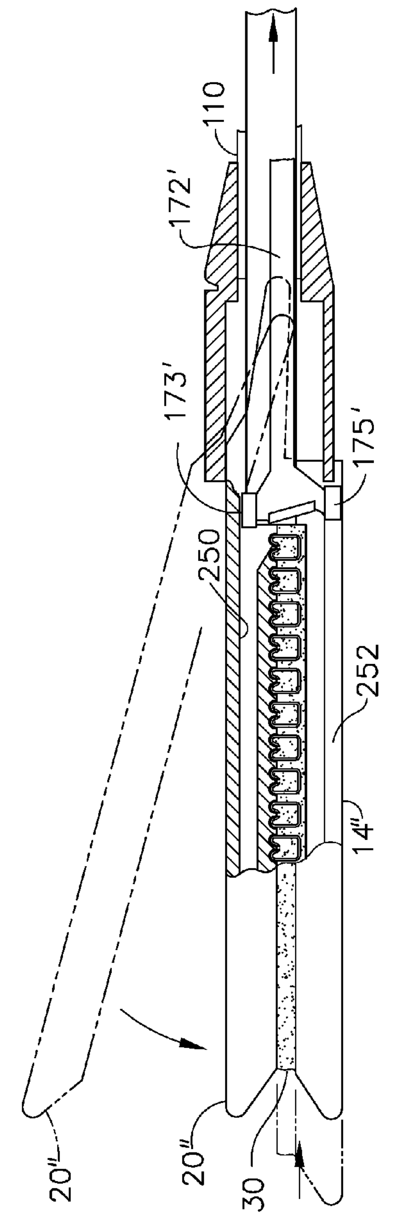


FIG. 4

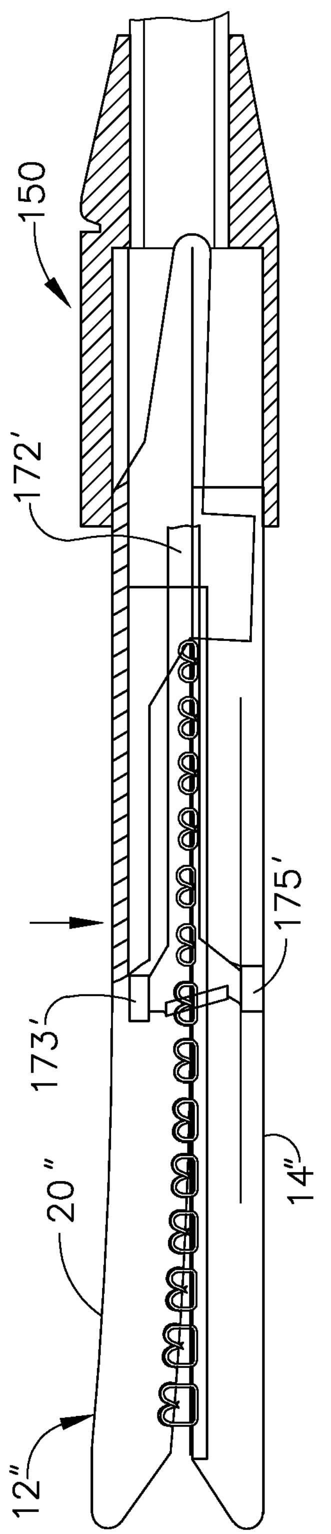
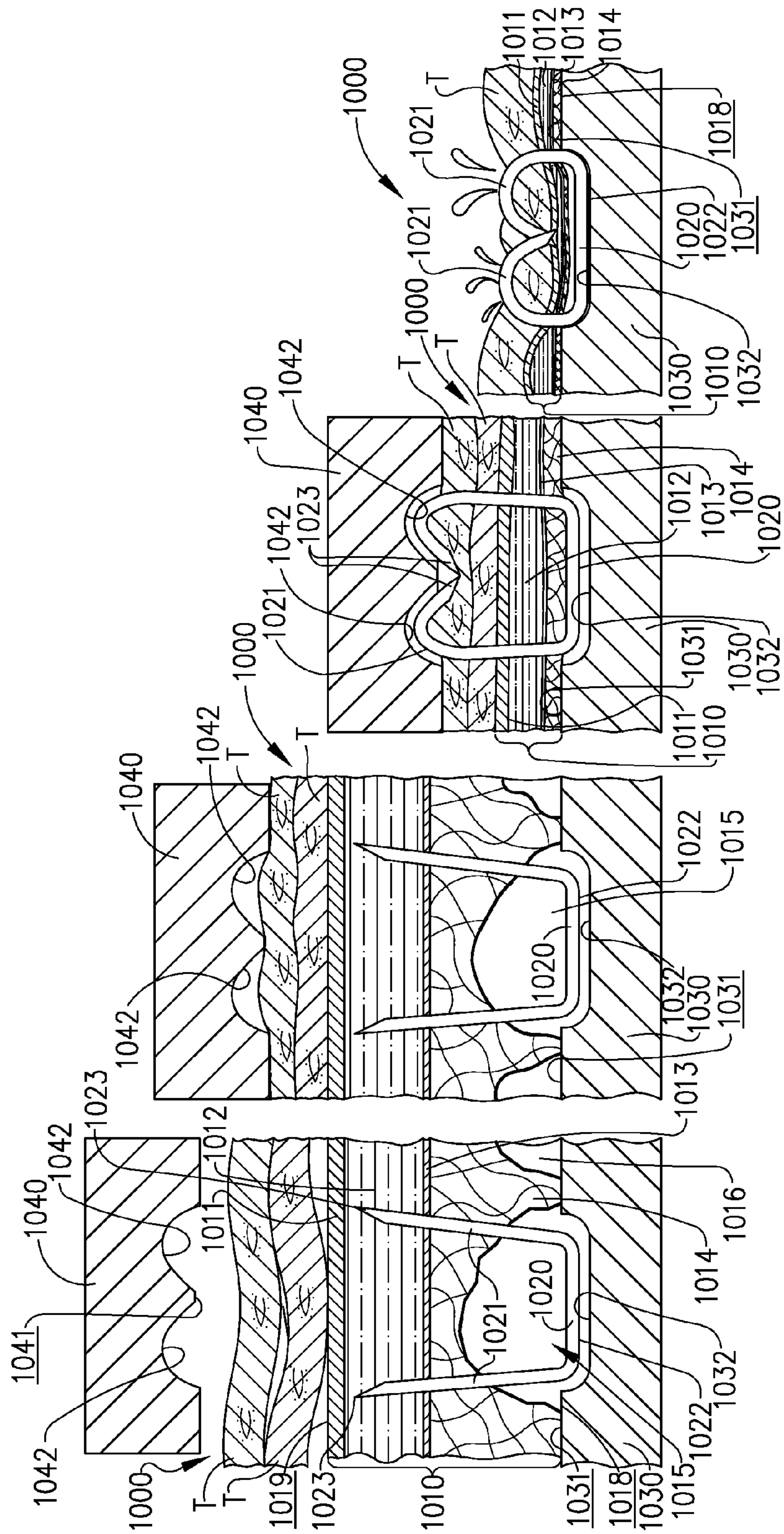


FIG. 5

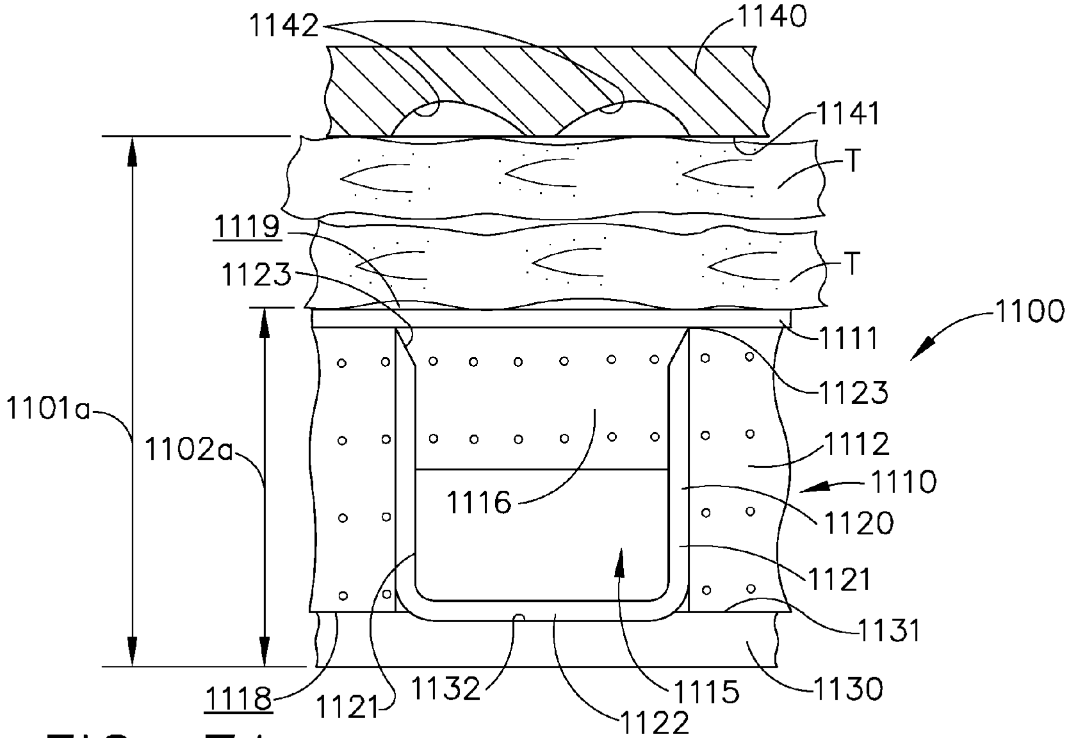


JAW OPEN
FIG. 6A

JAW CLOSED
FIG. 6B

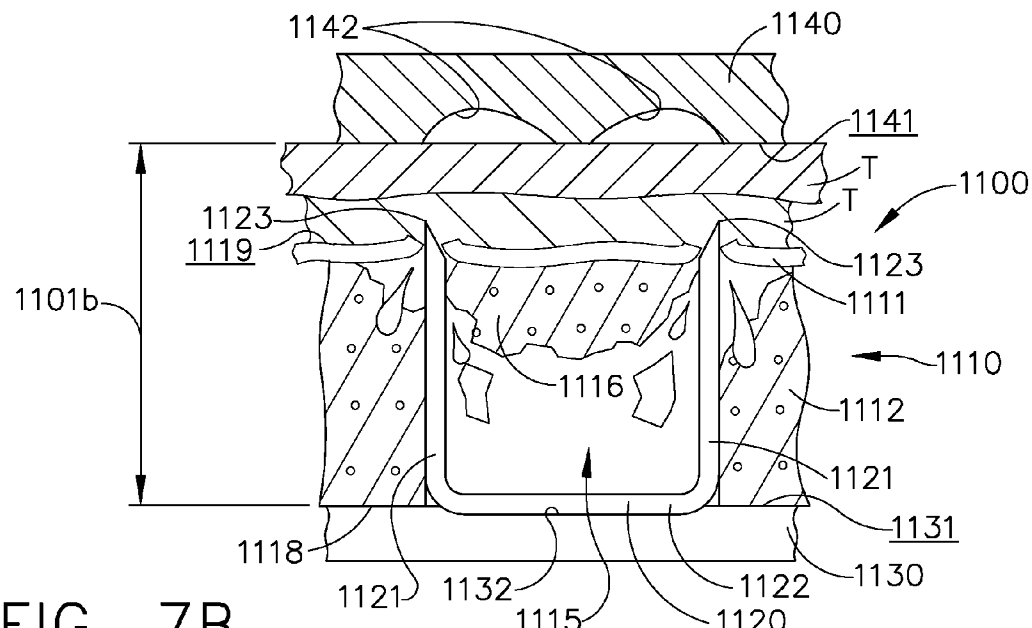
STAPLES FORMING
FIG. 6C

COMPLETELY FORMED
FIG. 6D



1142
1140
1141
T
1119
1123
T
1100
1111
1123
1101a
1102a
1112
1110
1116
1120
1121
1131
1118
1121
1132
1122
1115
1130

FIG. 7A



1142
1140
1141
T
T
1100
1123
1119
1123
1111
1101b
1110
1116
1112
1121
1131
1118
1130
1122
1121
1132
1115
1120

FIG. 7B

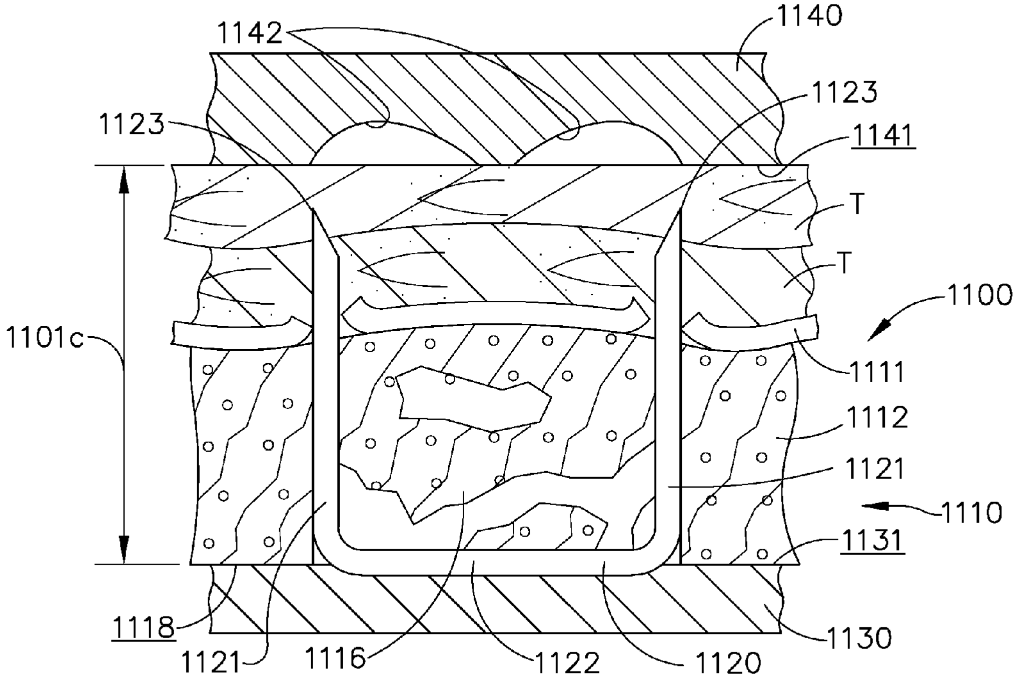

1142
1140
1123
1123
1141
T
T
1100
1101c
1111
1112
1121
1110
1131
1118
1121
1116
1122
1120
1130

FIG. 7C

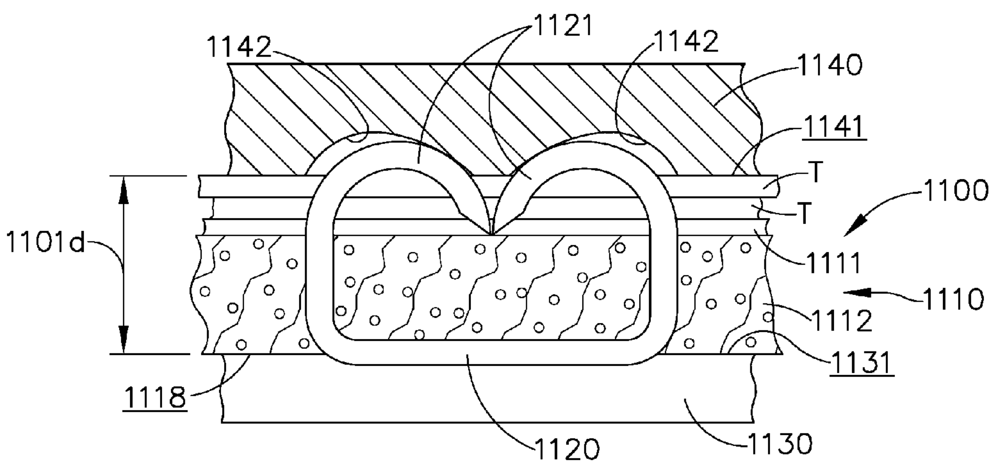

1121
1142
1142
1140
1141
T
T
1100
1101d
1111
1110
1112
1131
1118
1120
1130

FIG. 7D

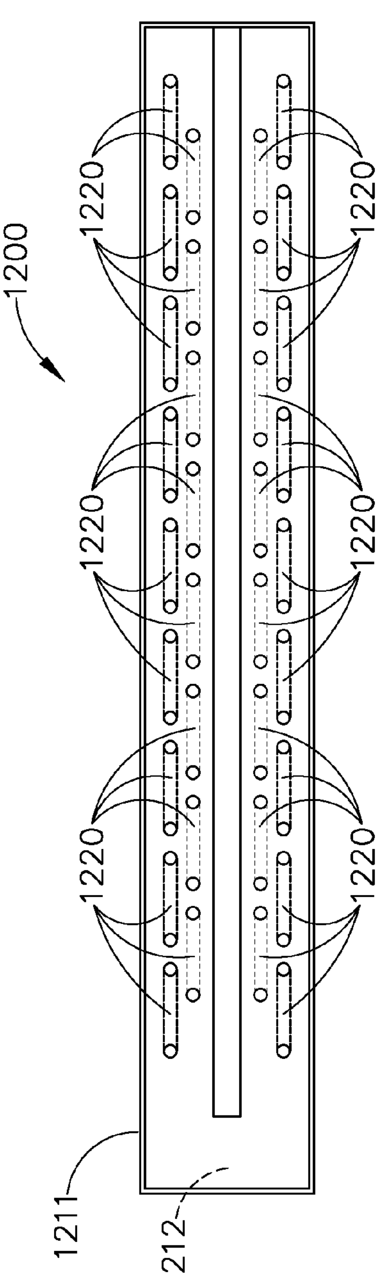

1200
1220
1220
1220
1220
1220
1220
1211
1212

FIG. 8

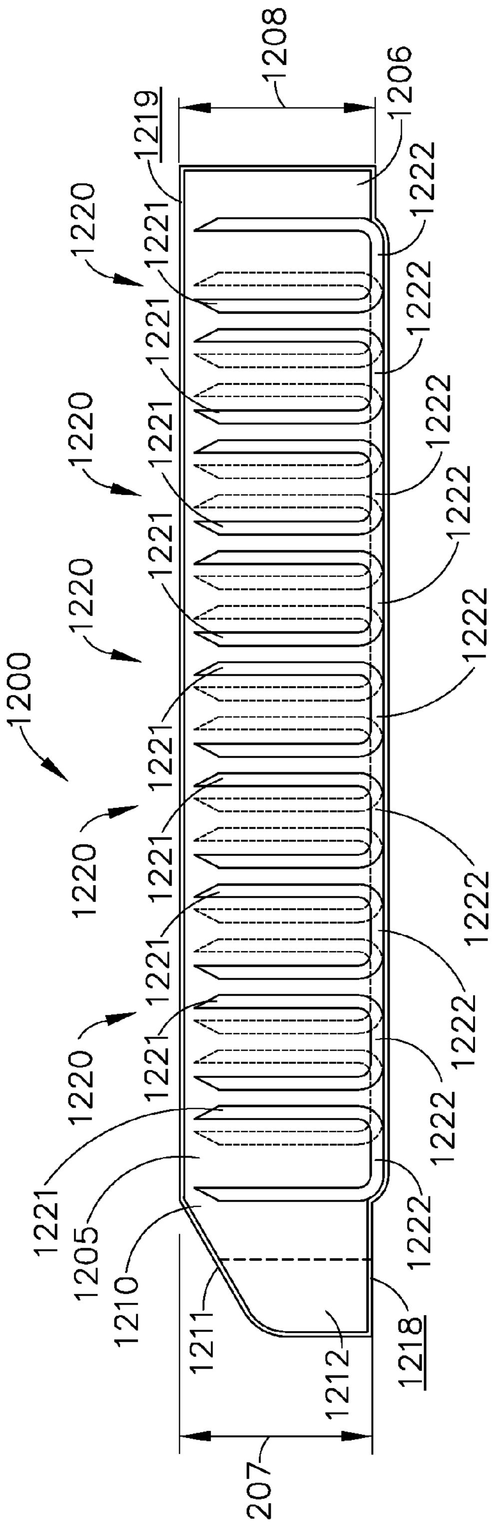

1208
1206
1219
1222
1221
1220
1200
1205
1210
1211
1212
1218
1207

FIG. 9

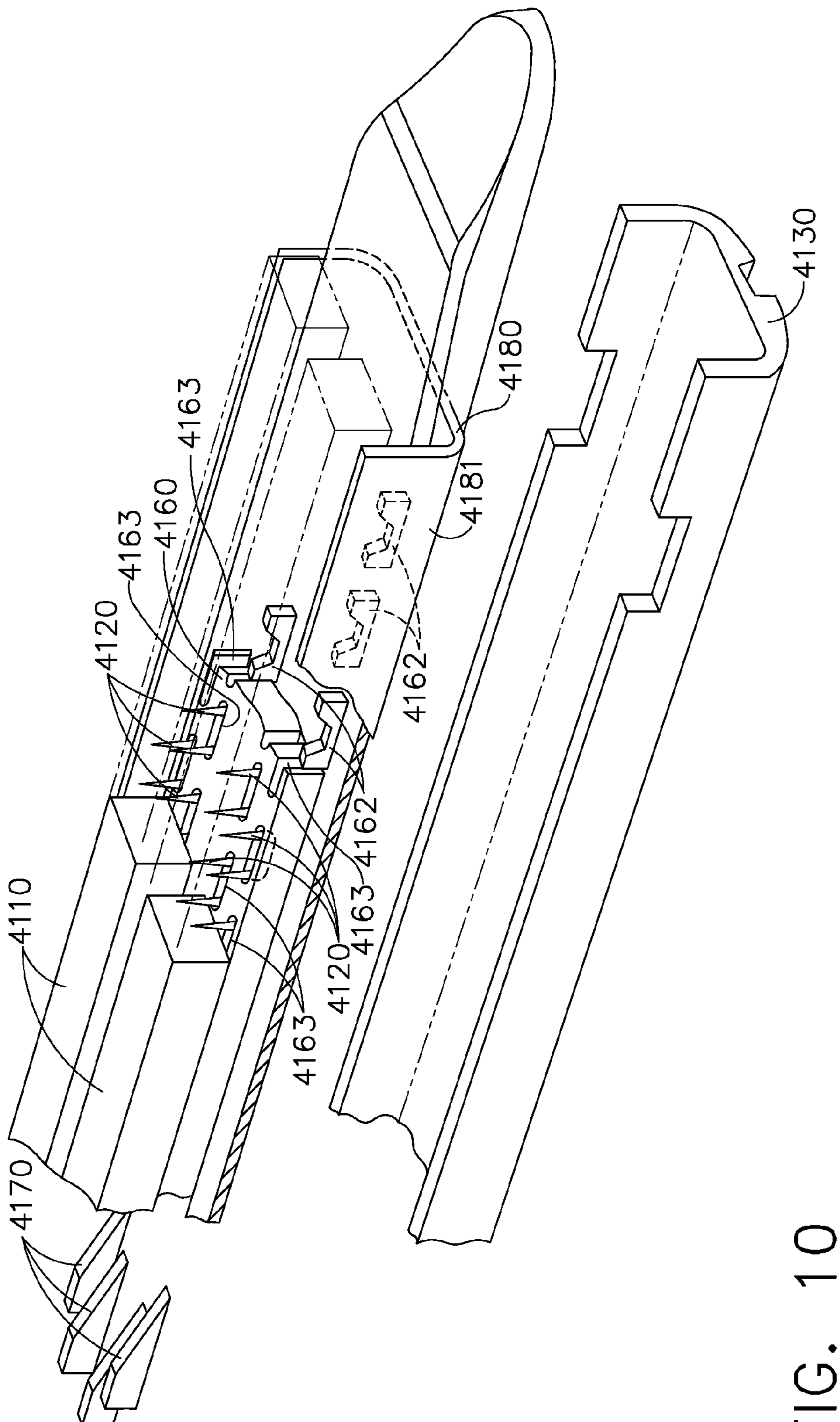

4110
4170
4120
4163
4160
4163
4180
4181
4162
4162
4163
4120
4163
4130

FIG. 10

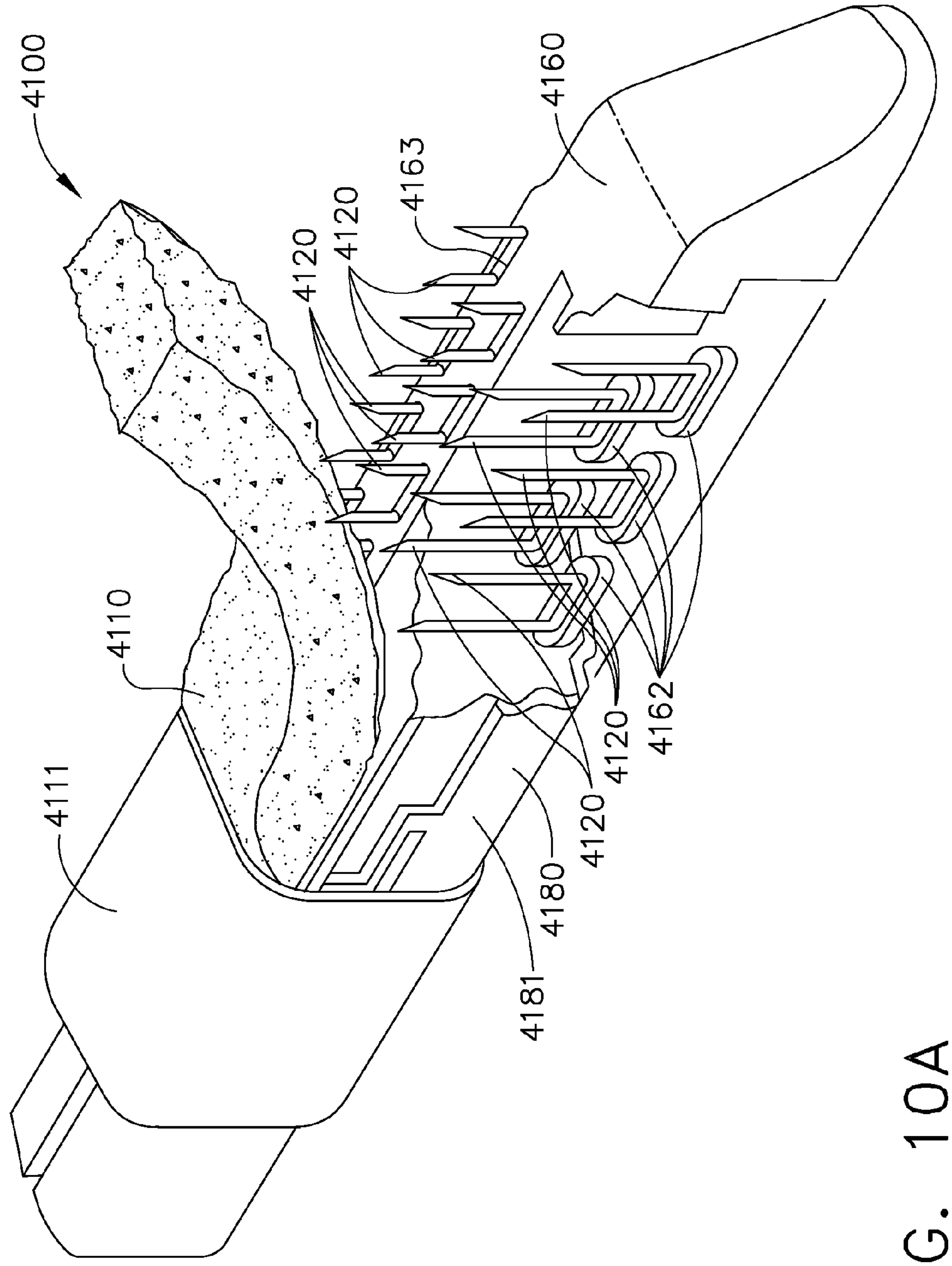

4100
4160
4163
4120
4120
4120
4110
4111
4162
4120
4120
4180
4181

FIG. 10A

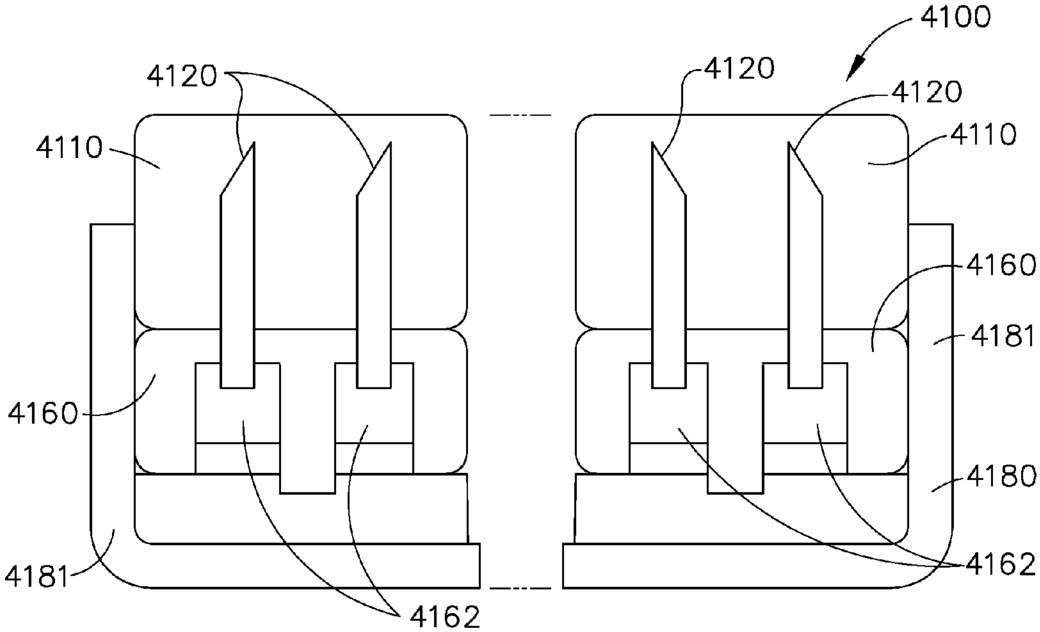


FIG. 11

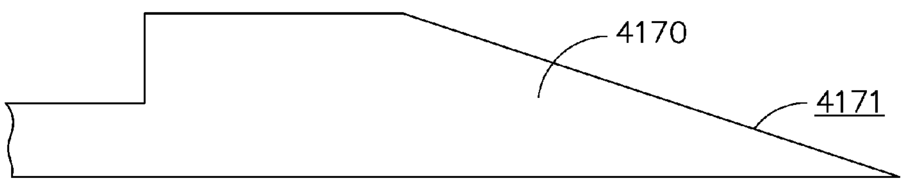


FIG. 12

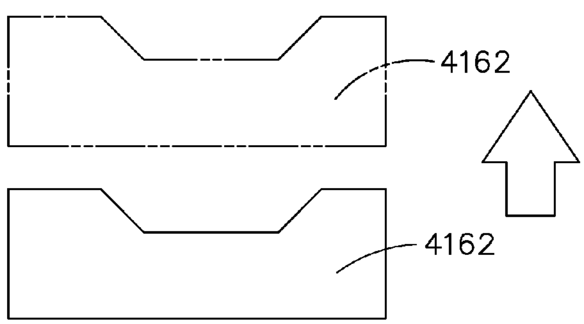


FIG. 13

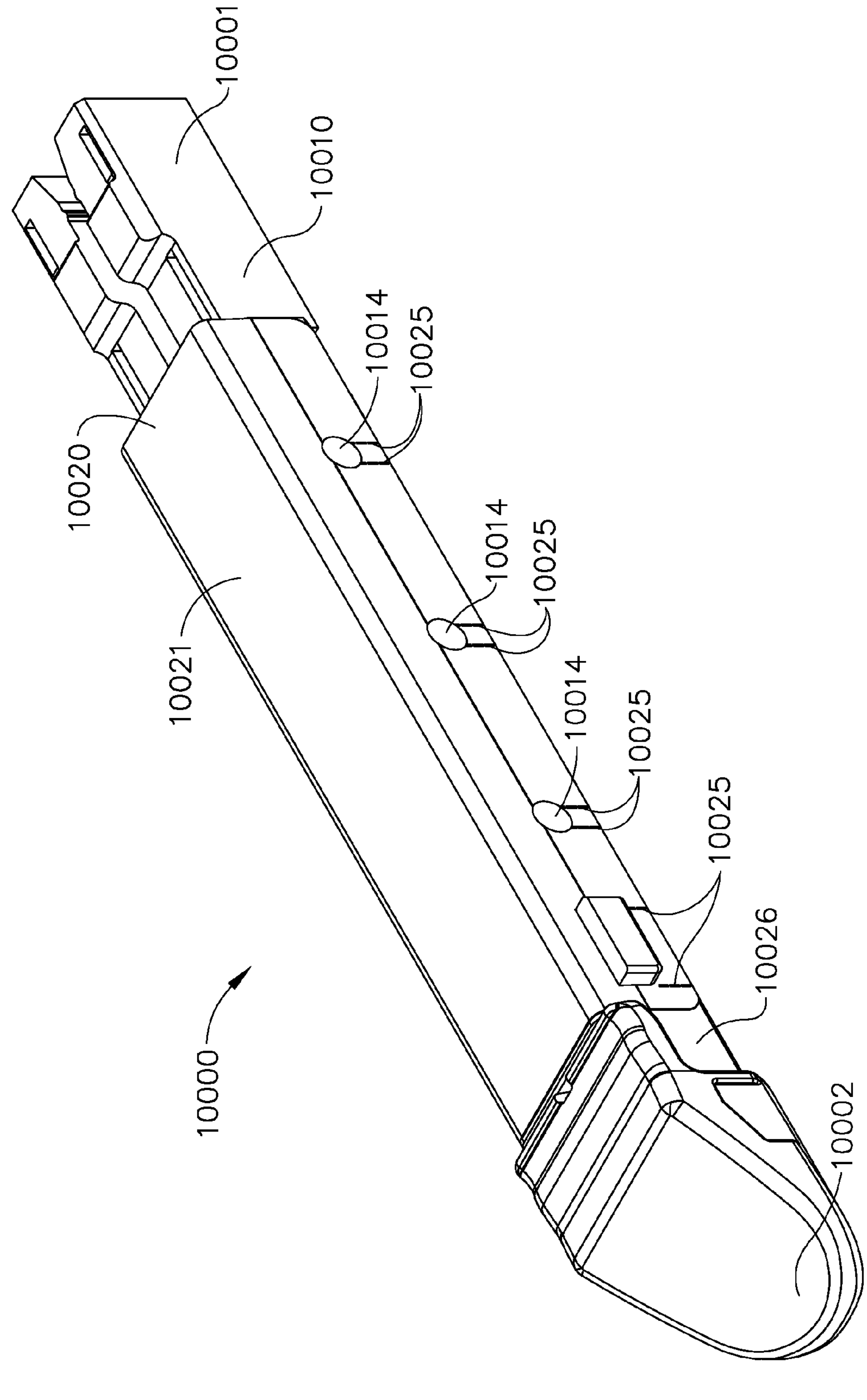

10001
10010
10014
10025
10020
10014
10025
10021
10014
10025
10025
10026
10000
10002

FIG. 14

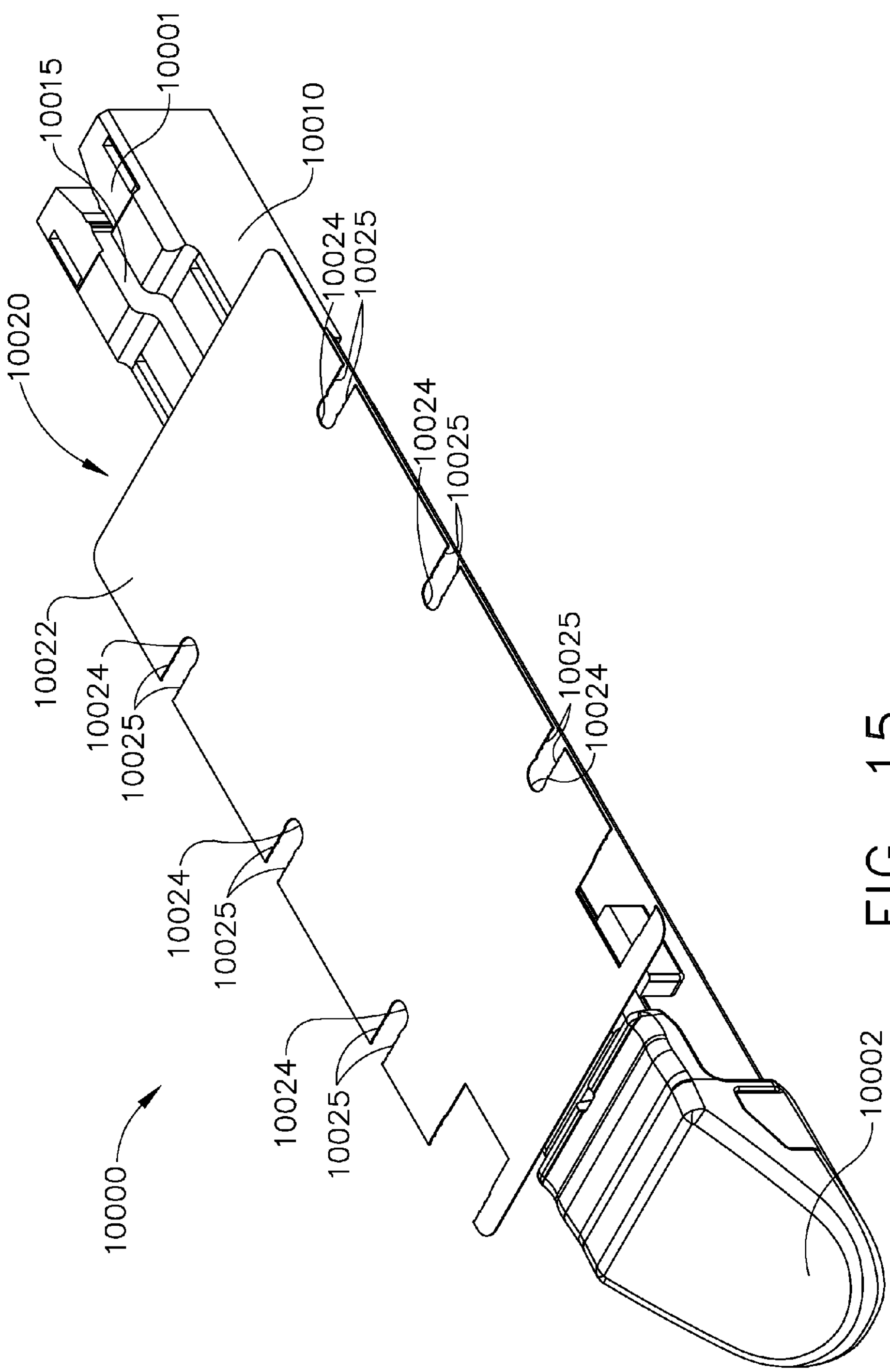


FIG. 15

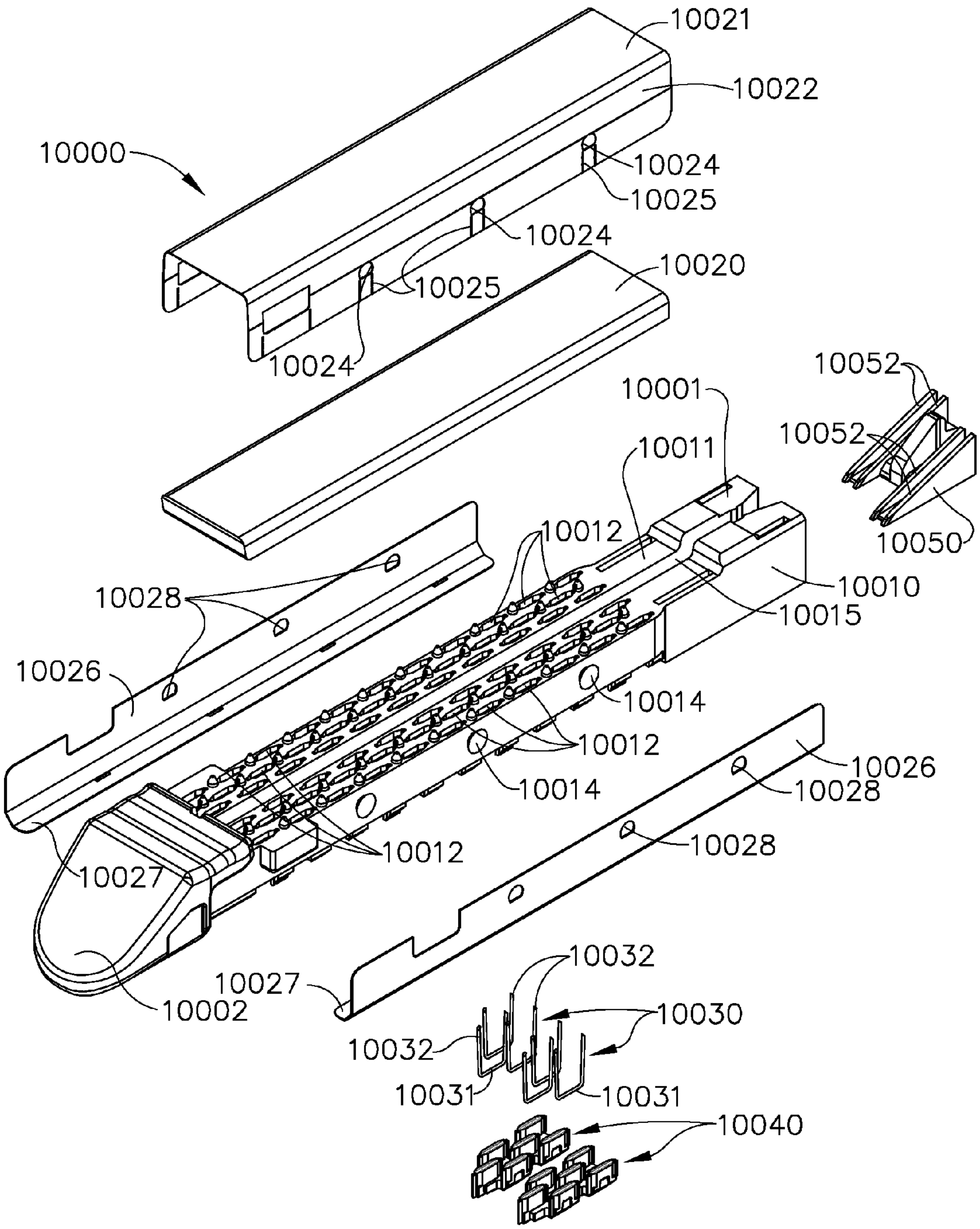

10000
10021
10022
10024
10025
10024
10020
10025
10024
10052
10001
10052
10011
10012
10050
10028
10010
10015
10026
10014
10012
10026
10014
10028
10012
10028
10027
10002
10027
10032
10030
10032
10031
10031
10040

FIG. 16

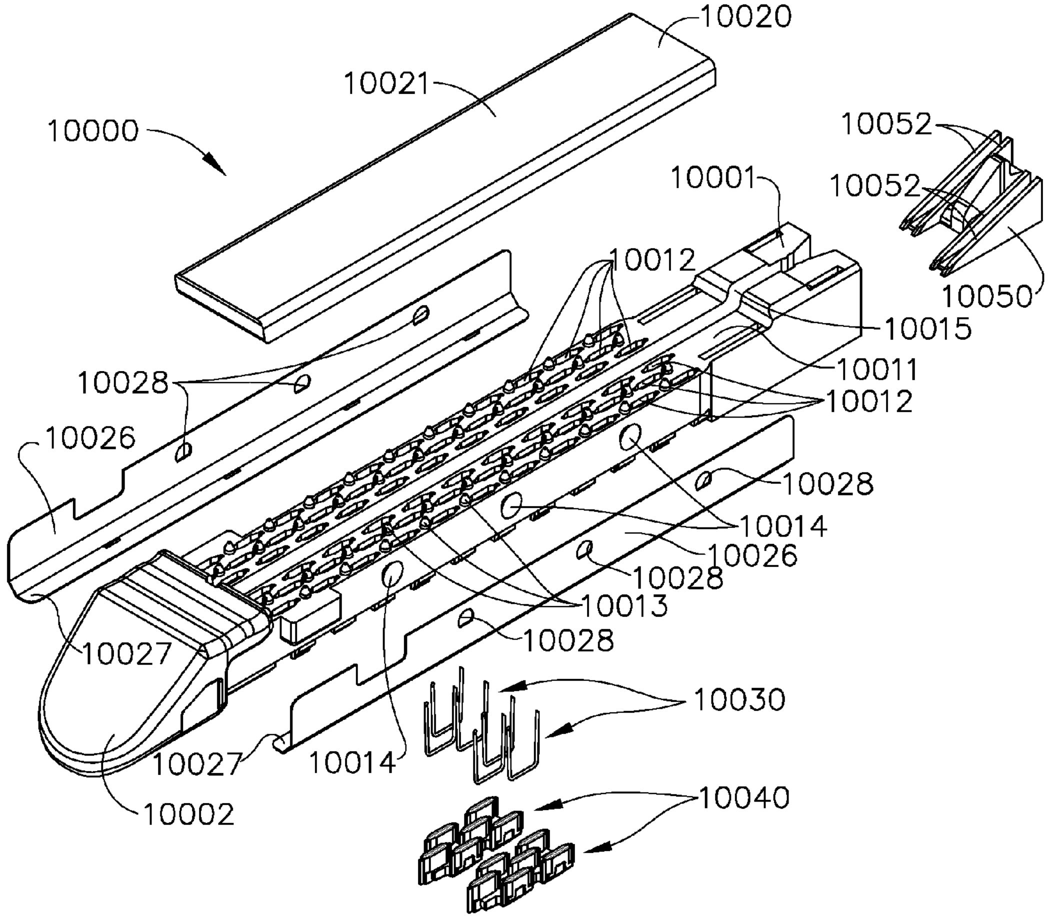

10020
10021
10000
10052
10052
10001
10012
10050
10015
10011
10028
10012
10026
10028
10014
10026
10028
10013
10027
10028
10030
10027
10014
10002
10040

FIG. 17

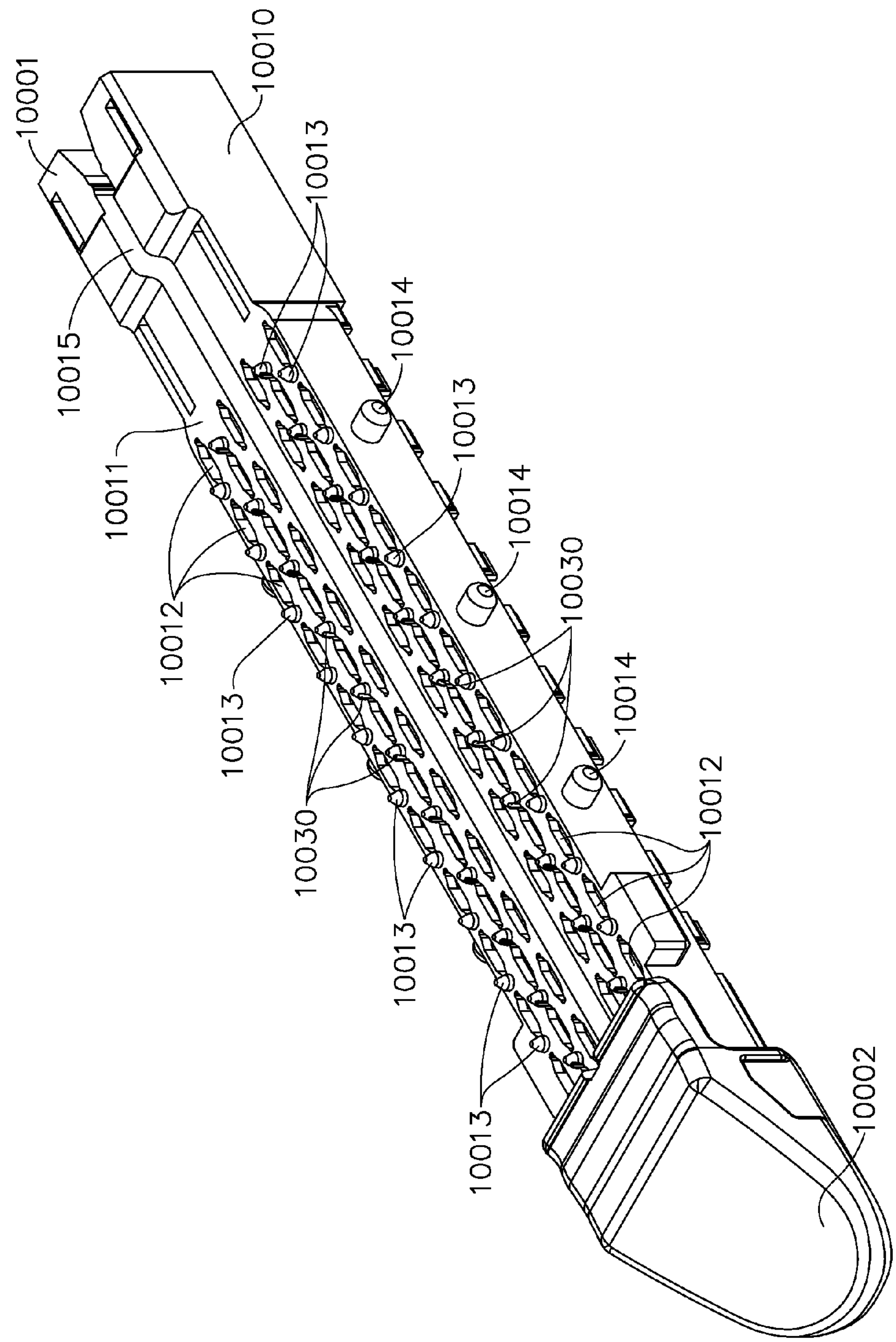

10001
10010
10013
10015
10014
10011
10013
10014
10012
10030
10013
10014
10030
10012
10013
10013
10002

FIG. 18

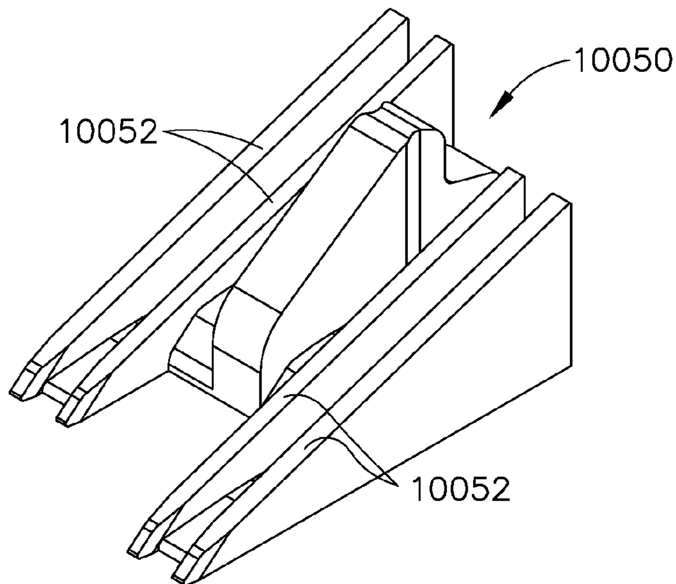


FIG. 19

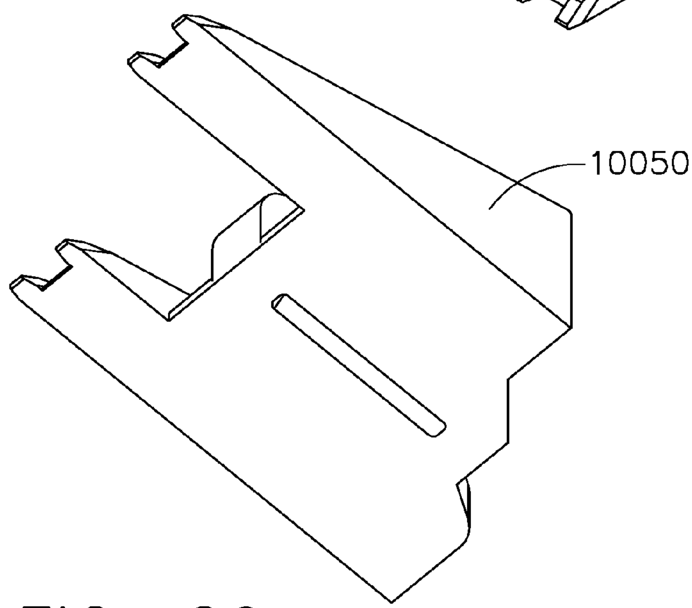


FIG. 20

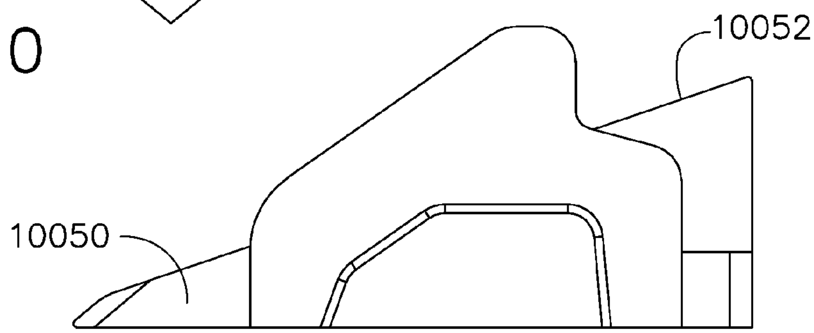


FIG. 21

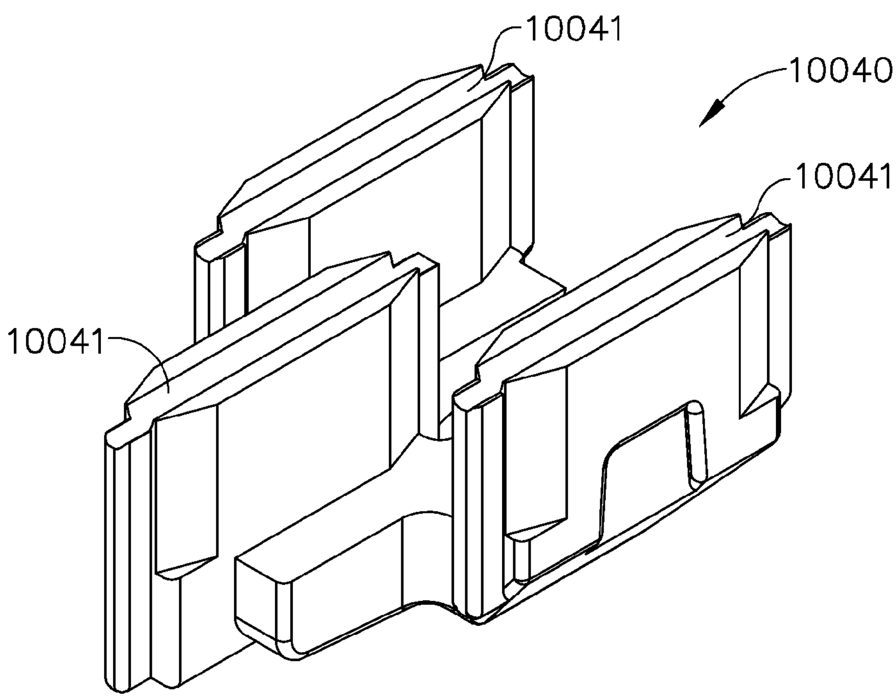


FIG. 22

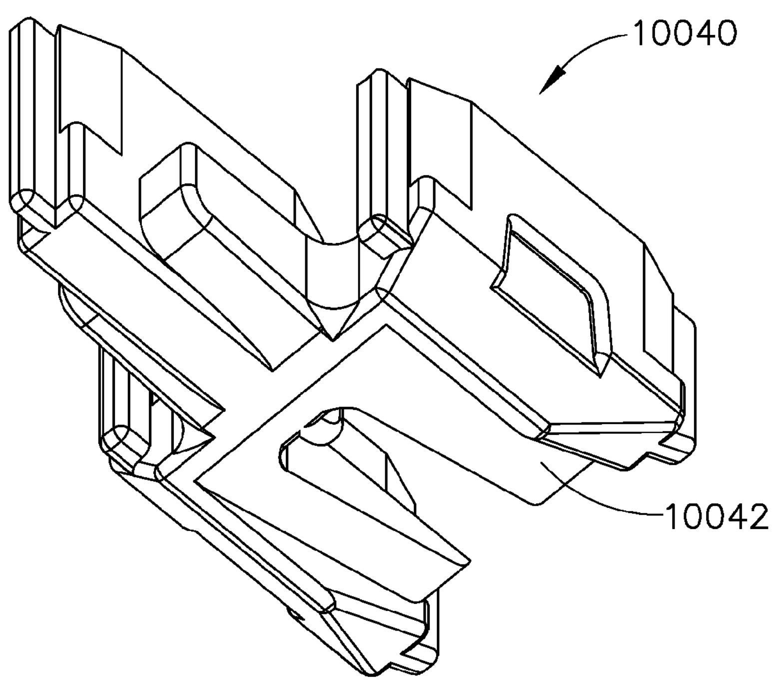


FIG. 23

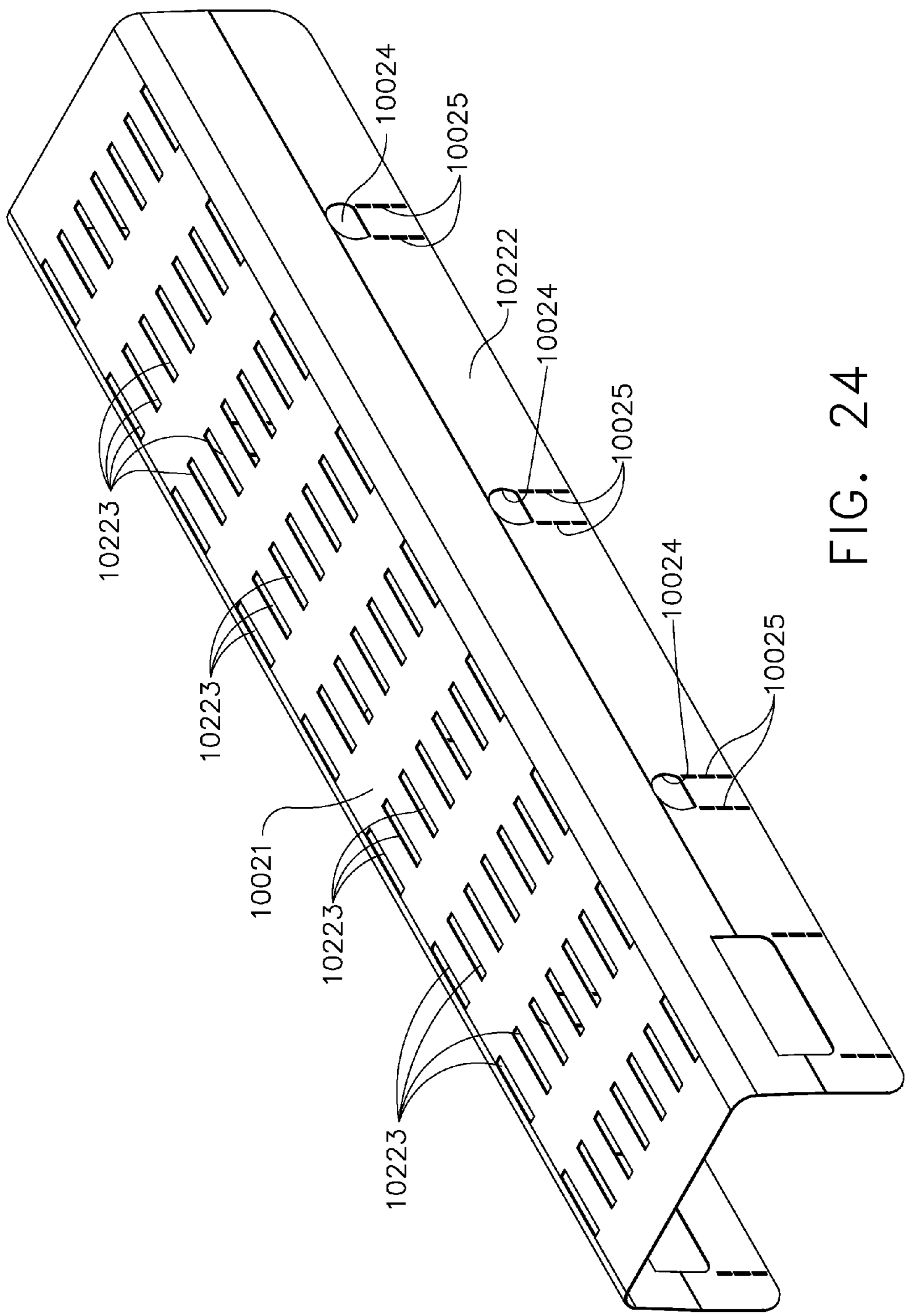

10024
10025
10222
10024
10025
10024
10025
10223
10223
10021
10223
10223

FIG. 24

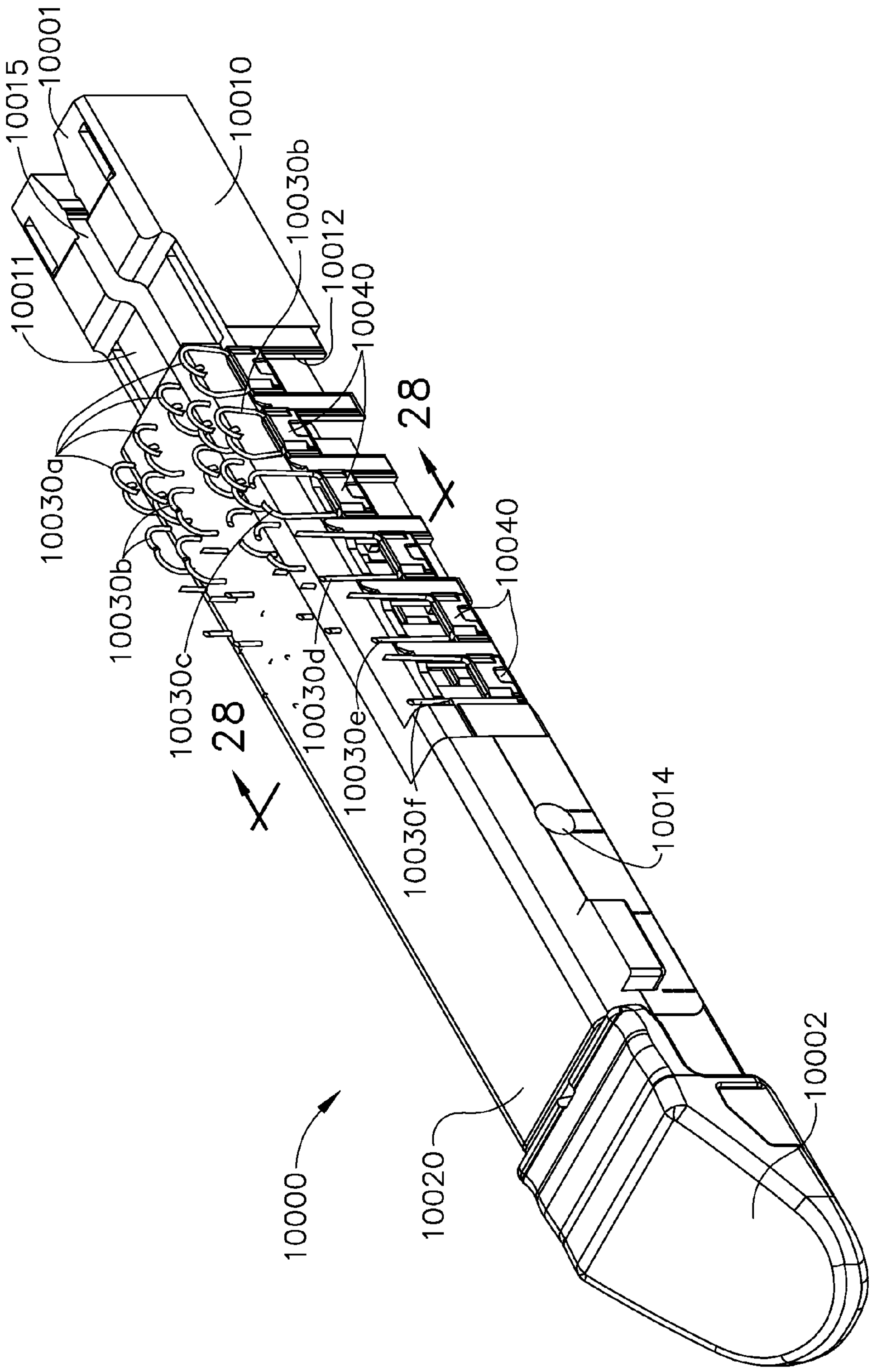

10001
10015
10010
10030b
10011
10012
10040
28
10030a
10030b
10040
10030c
10030d
10030e
28
10030f
10014
10002
10020
10000

FIG. 25

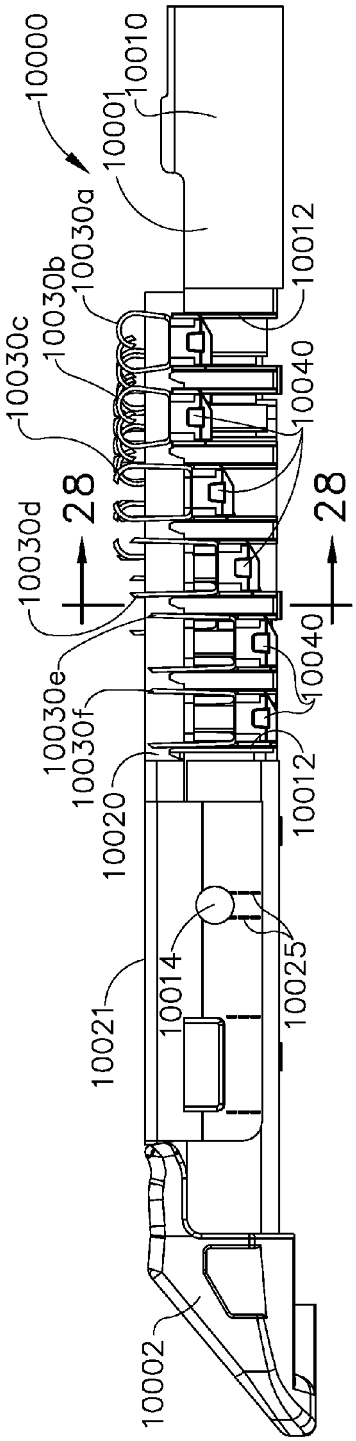

10000
10010
10001
10012
10030a
10030b
10030c
10040
28
10030d
10030e
10030f
10020
10021
10014
10025
10002

FIG. 26

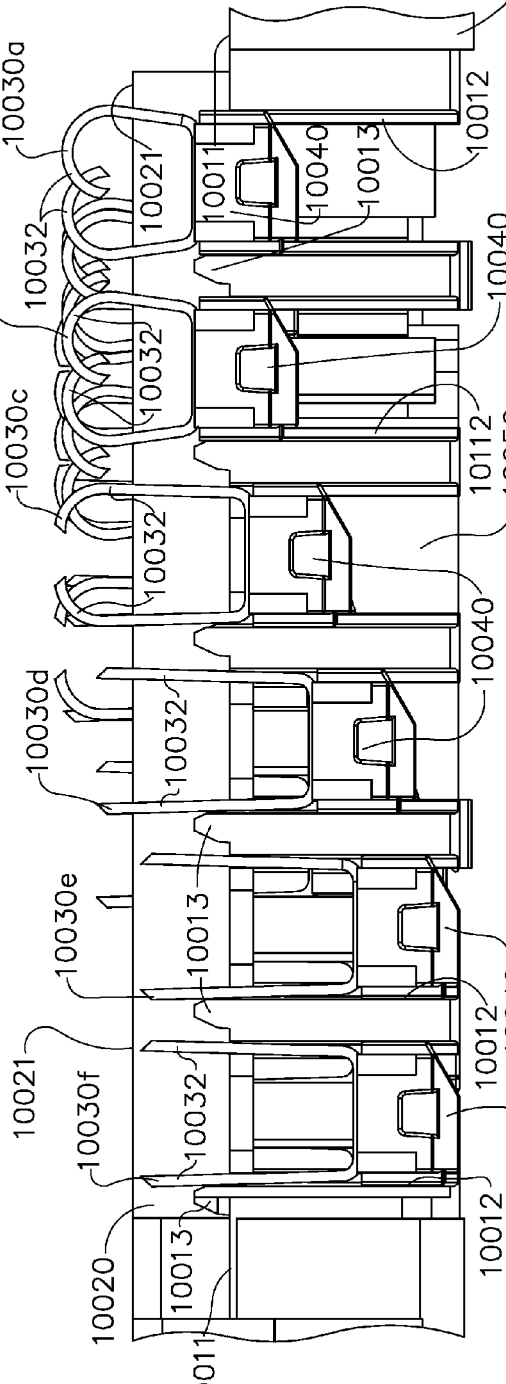

10010
10012
10030a
10021
10011
10040
10013
10030b
10032
10112
10050
10030c
10030d
10030e
10030f
10020

FIG. 27

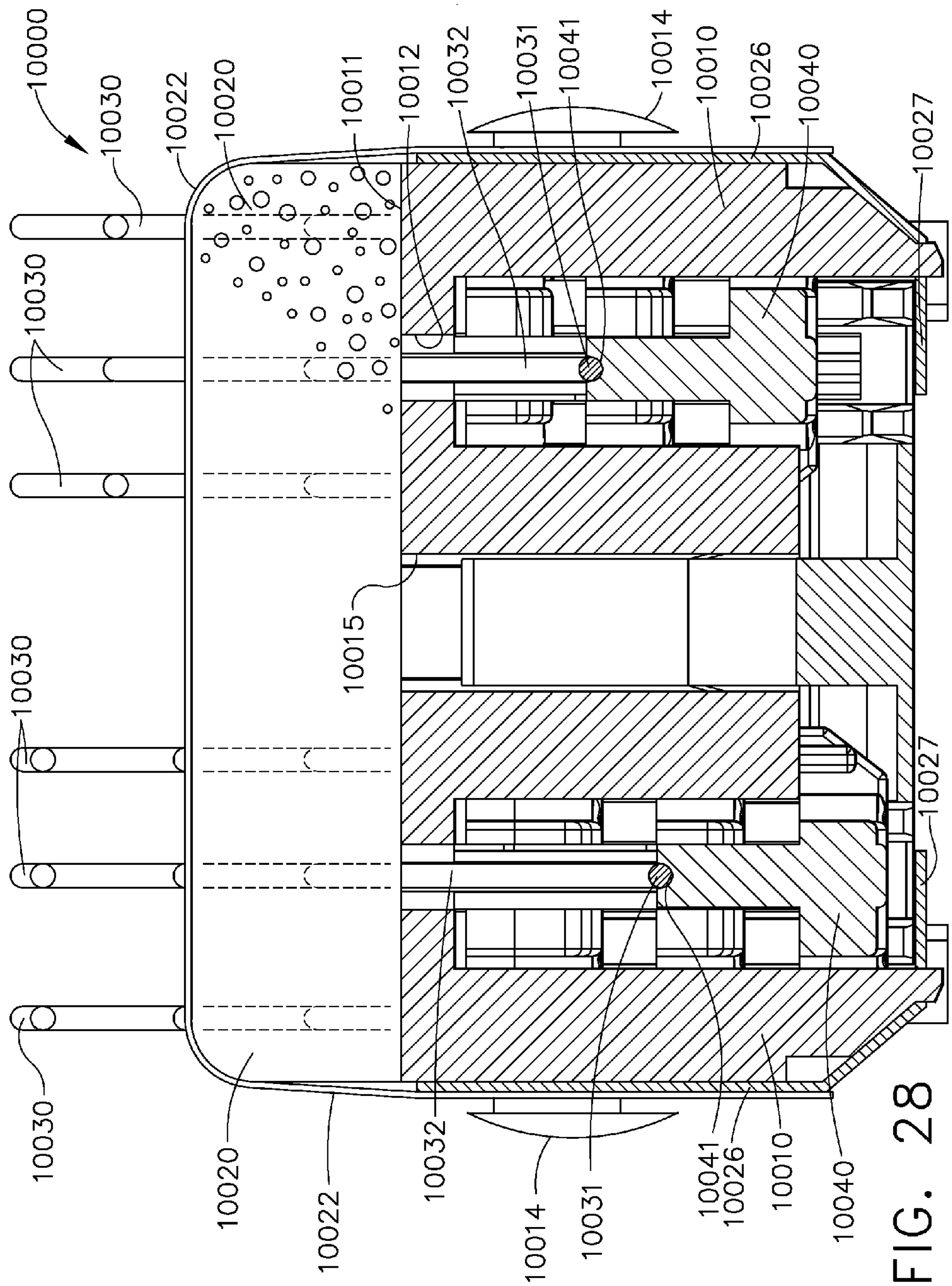

10000
10030
10022
10020
10011
10012
10032
10031
10041
10014
10010
10026
10040
10027
10015
10030
10027
10030
10020
10022
10032
10014
10031
10041
10026
10010
10040

FIG. 28

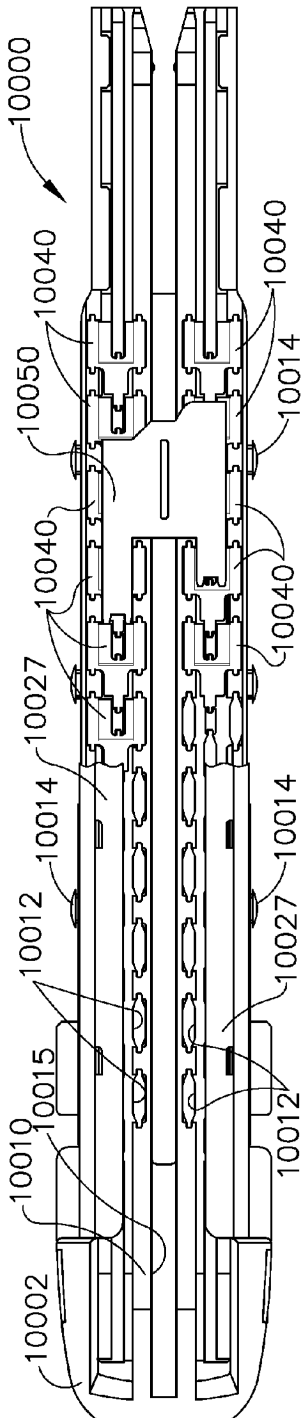

10000
10040
10040
10050
10014
10040
10040
10040
10027
10014
10014
10012
10027
10015
10012
10010
10002

FIG. 29

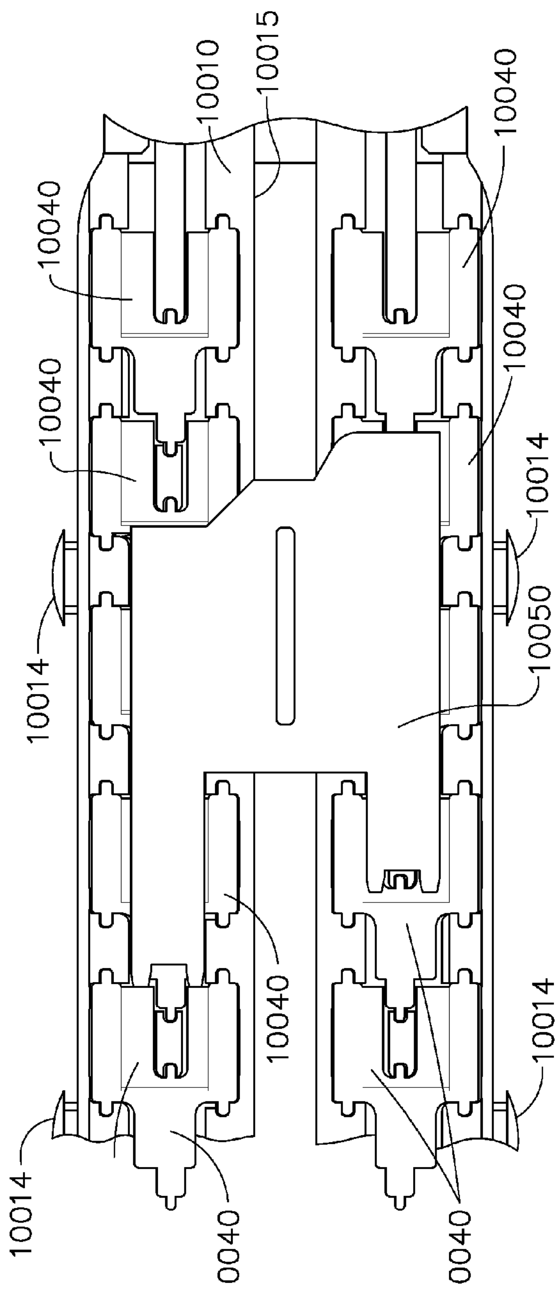

10010
10015
10040
10040
10040
10040
10014
10014
10050
10014
10040
10014
10014
10040
10040

FIG.30

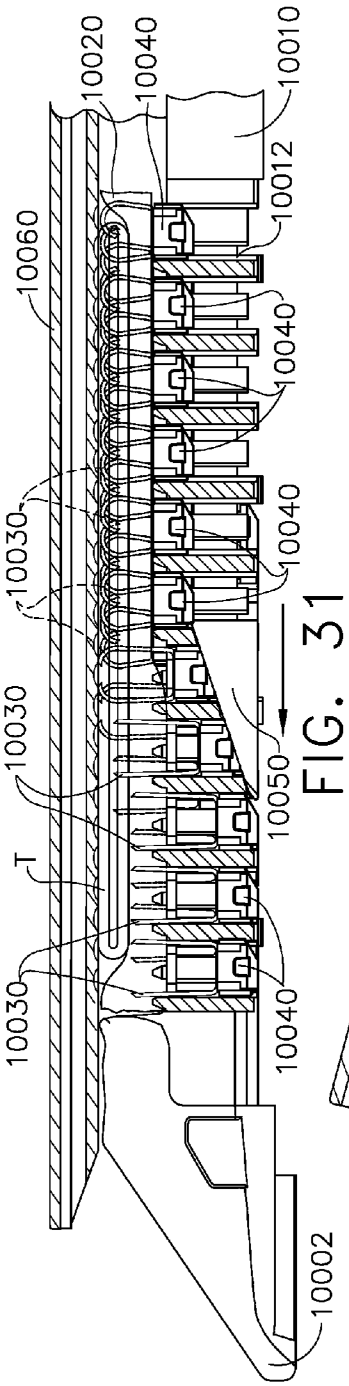

10060
10020
10040
10010
10012
10040
10040
10040
10030
10030
10030
T
10040
10050
10002

FIG. 31

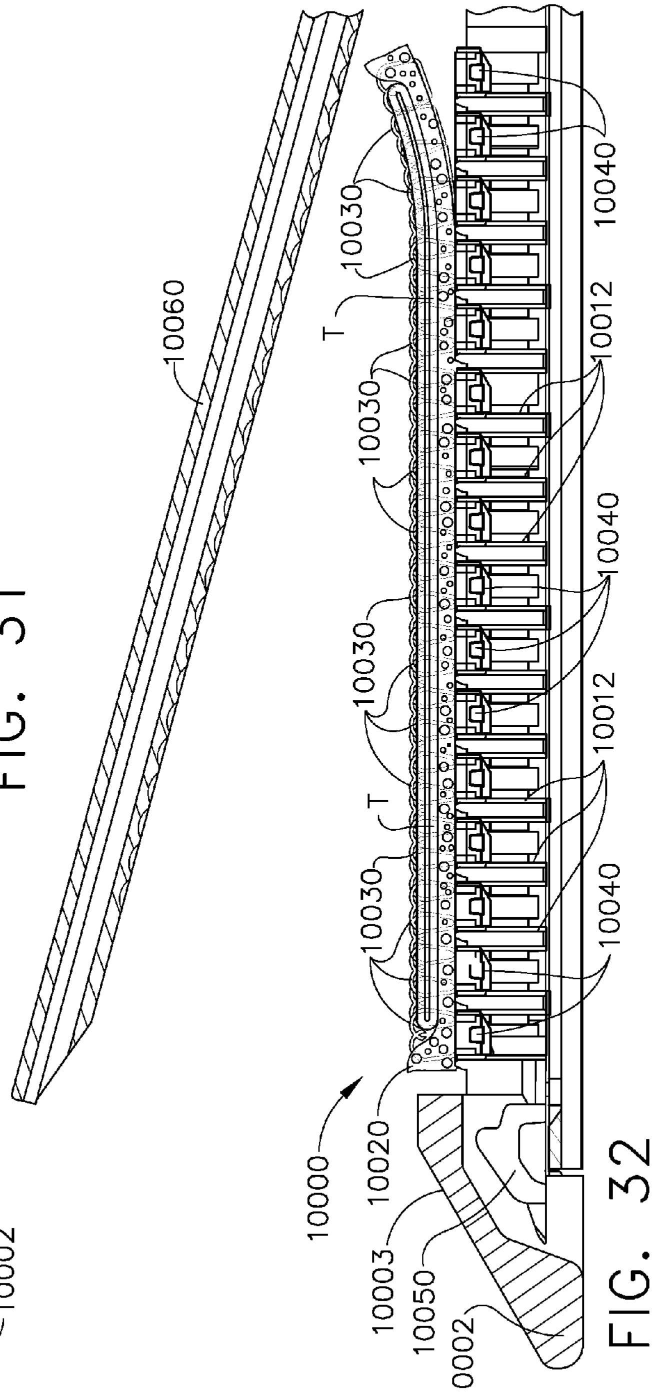

10060
10030
T
10030
10030
10030
10030
T
10040
10012
10040
10012
10040
10000
10020
10003
10050
10002

FIG. 32

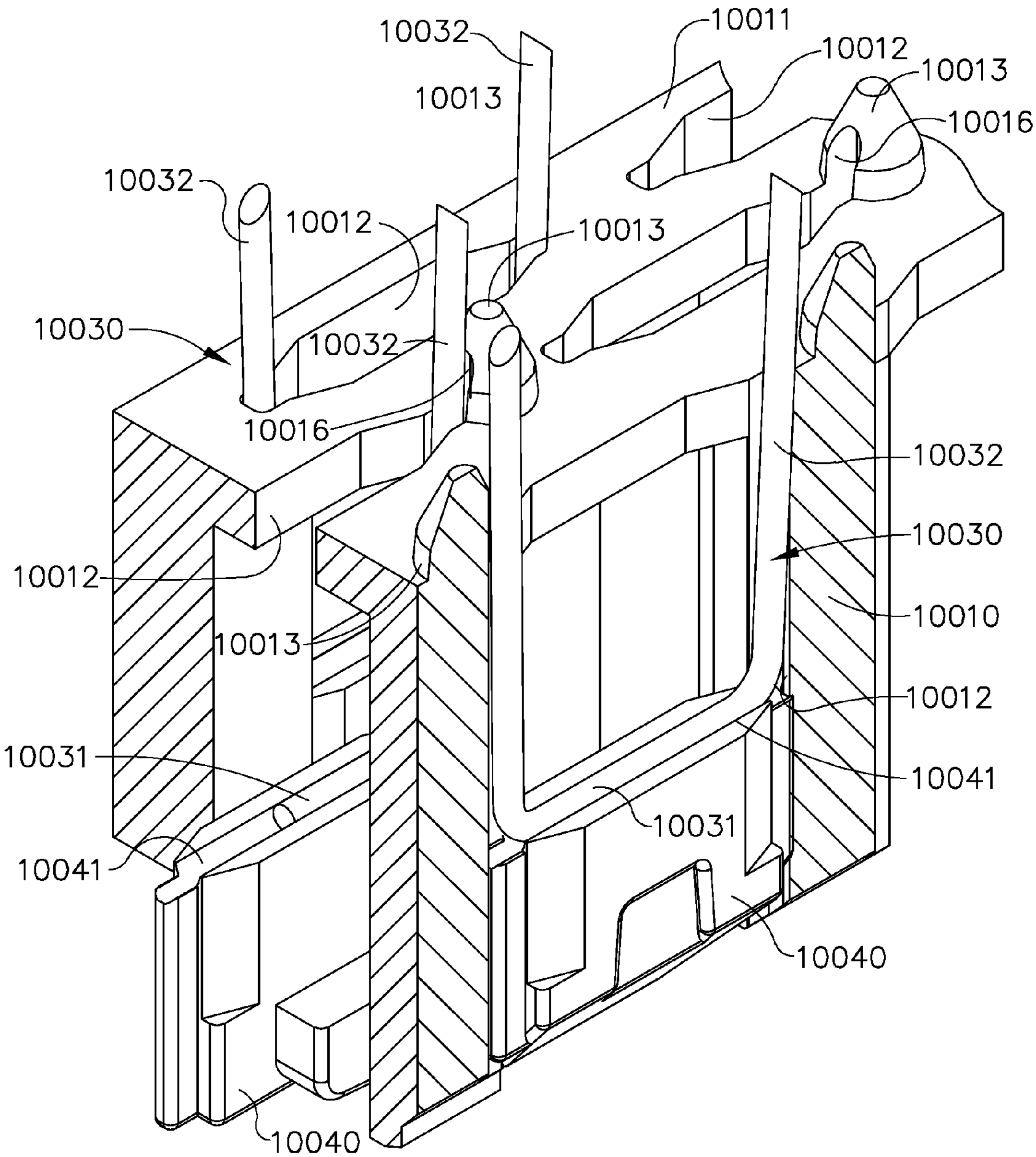

10032
10011
10012
10013
10016
10013
10032
10012
10013
10030
10032
10016
10032
10030
10012
10010
10013
10012
10031
10041
10041
10031
10040
10040

FIG. 33

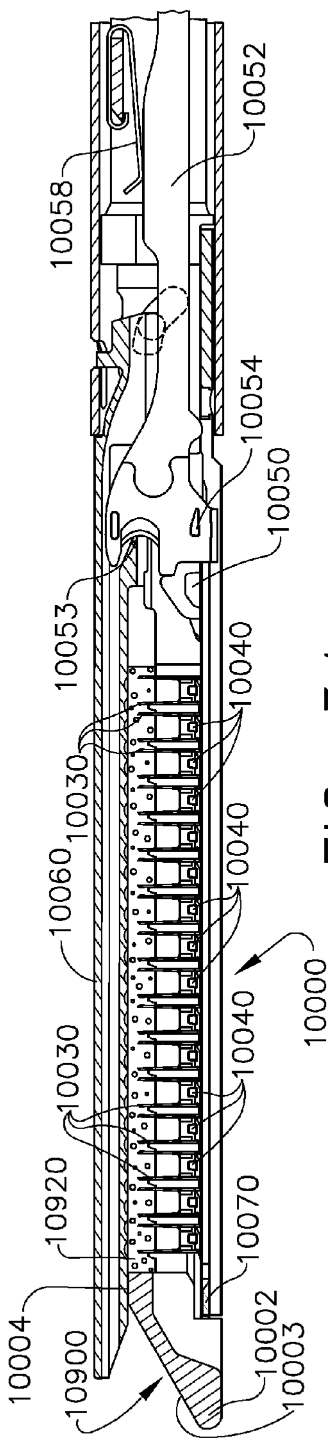

10058
10052
10054
10050
10053
10040
10030
10060
10040
10000
10030
10920
10070
10004
10900
10002
10003

FIG. 34

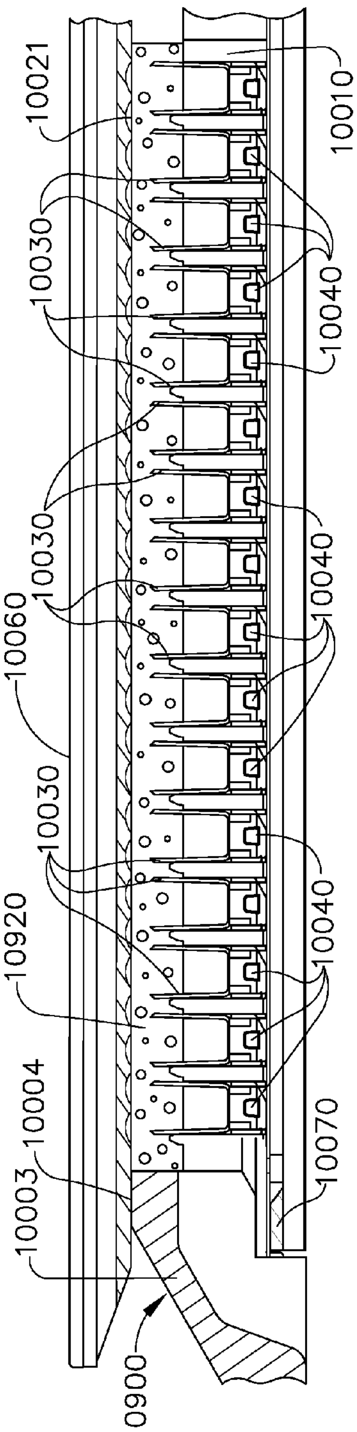
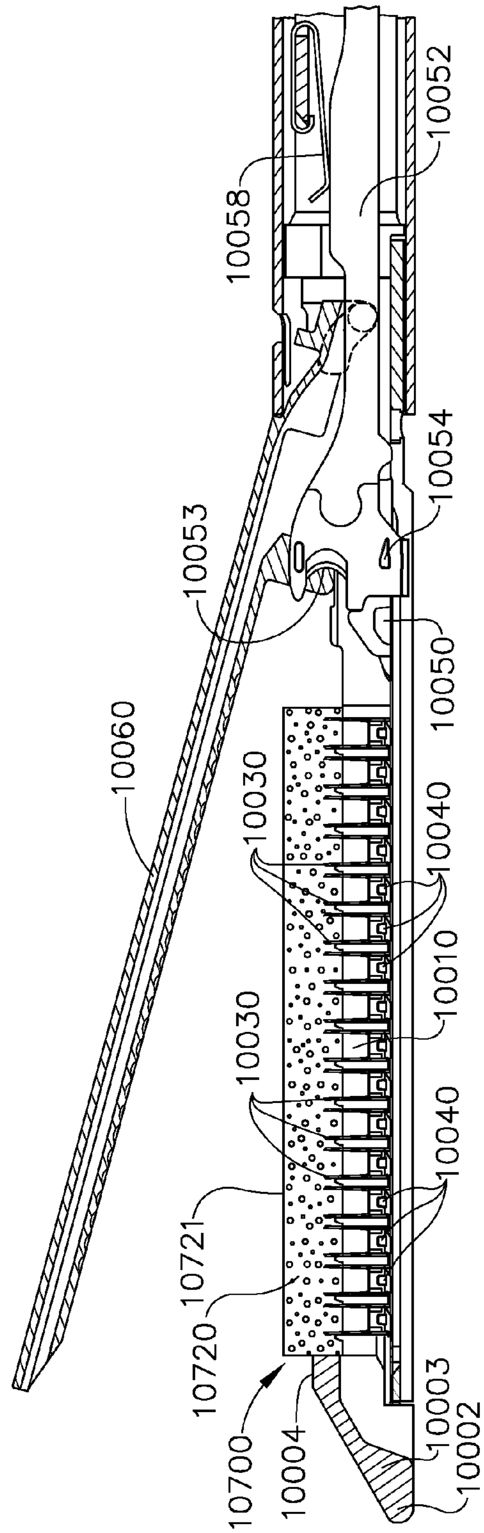

10021
10010
10030
10040
10060
10920
10004
10003
10070
10900

FIG. 35



10052
10058
10054
10053
10050
10060
10030
10040
10010
10030
10040
10721
10720
10700
10004
10003
10002

FIG. 36

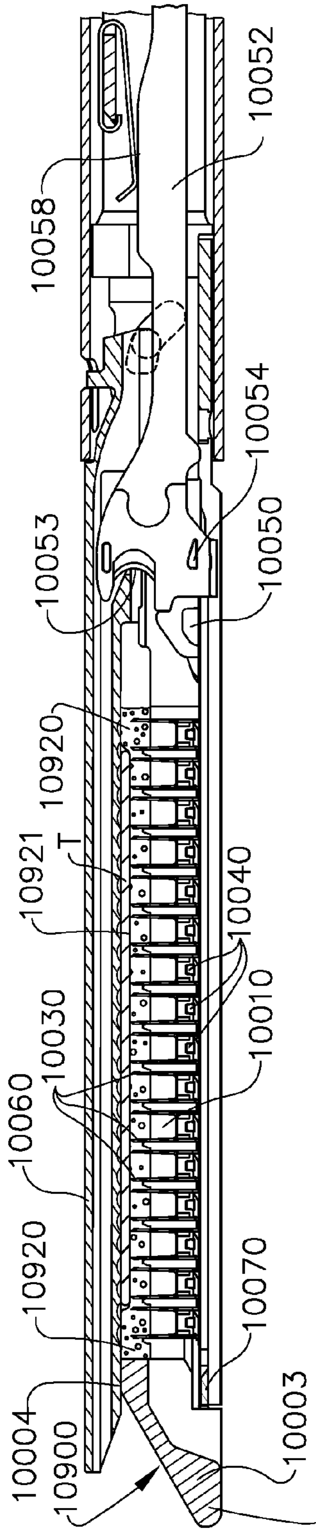

10052
10058
10054
10053
10050
10920
T
10921
10040
10030
10010
10060
10920
10070
10004
10900
10003
10002

FIG. 37

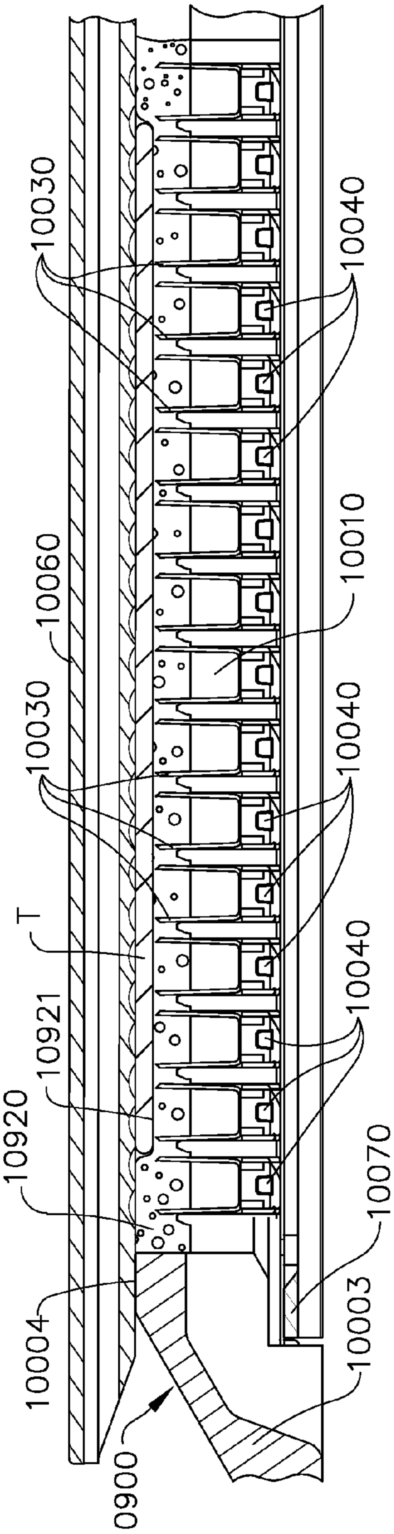

10030
10040
10010
10060
10030
10040
T
10040
10921
10920
10070
10004
10003
10900

FIG. 38

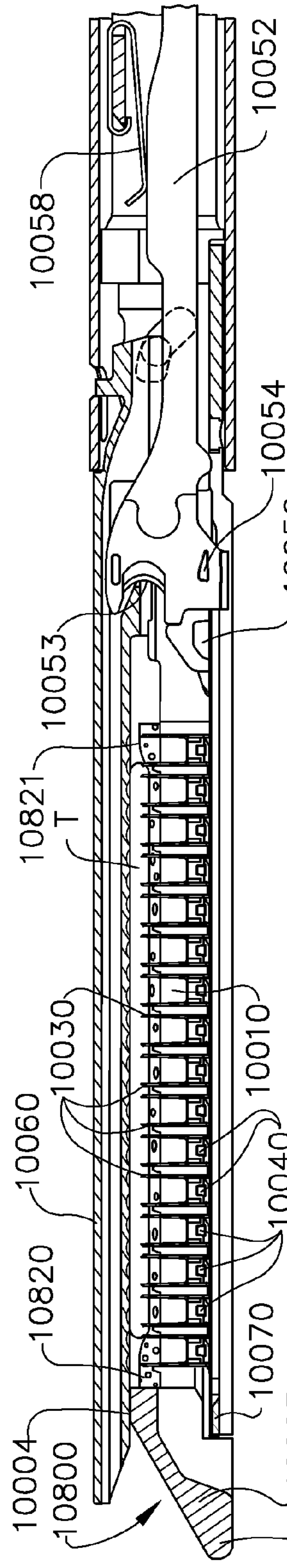

10058
10052
10054
10050
10053
10821
T
10030
10010
10060
10040
10820
10070
10003
10004
10800
10002

FIG. 39

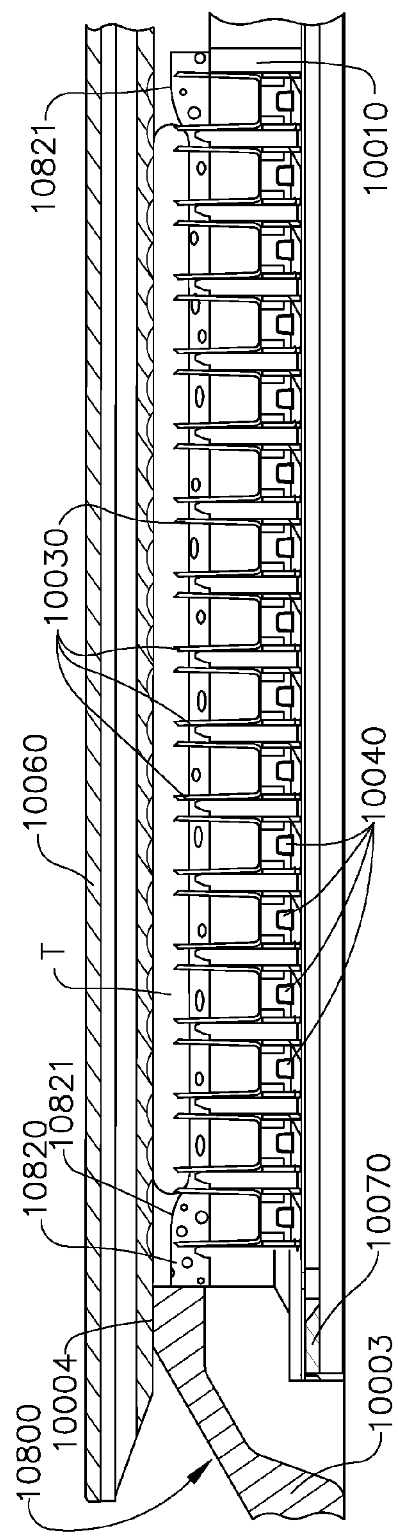

10821
10010
10030
10060
T
10040
10820
10821
10070
10800
10004
10003

FIG. 40

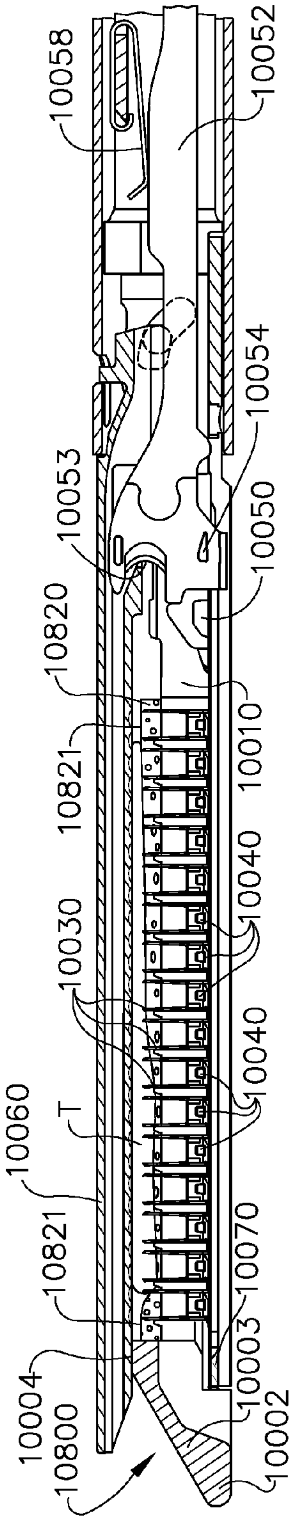

10058
10052
10054
10053
10050
10820
10010
10821
10040
10030
10060
T
10070
10004
10800
10003
10002

FIG. 41

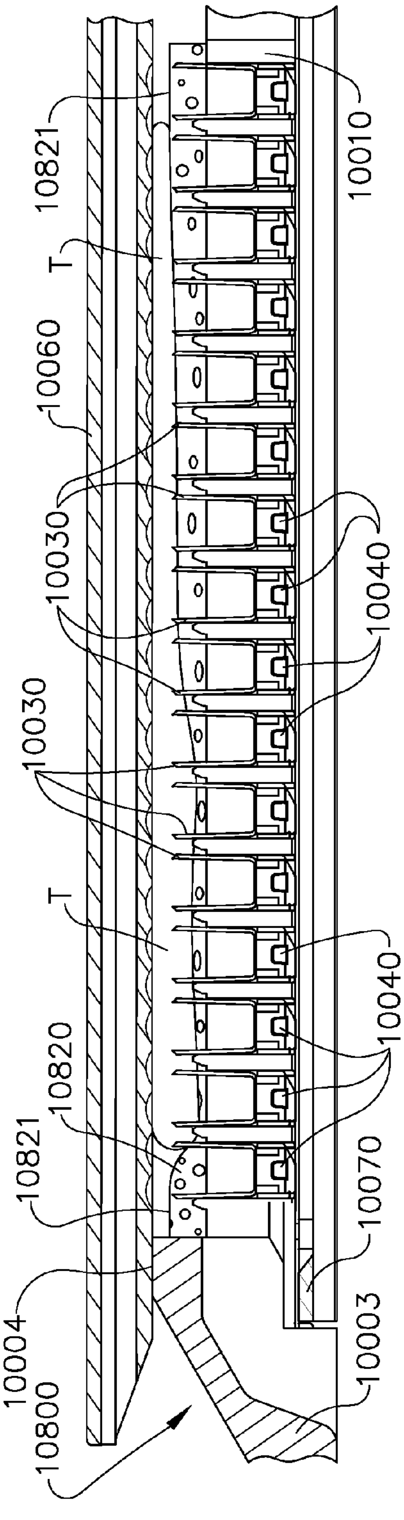

10821
10010
T
10060
10030
10040
10820
10070
10004
10800
10003

FIG. 42

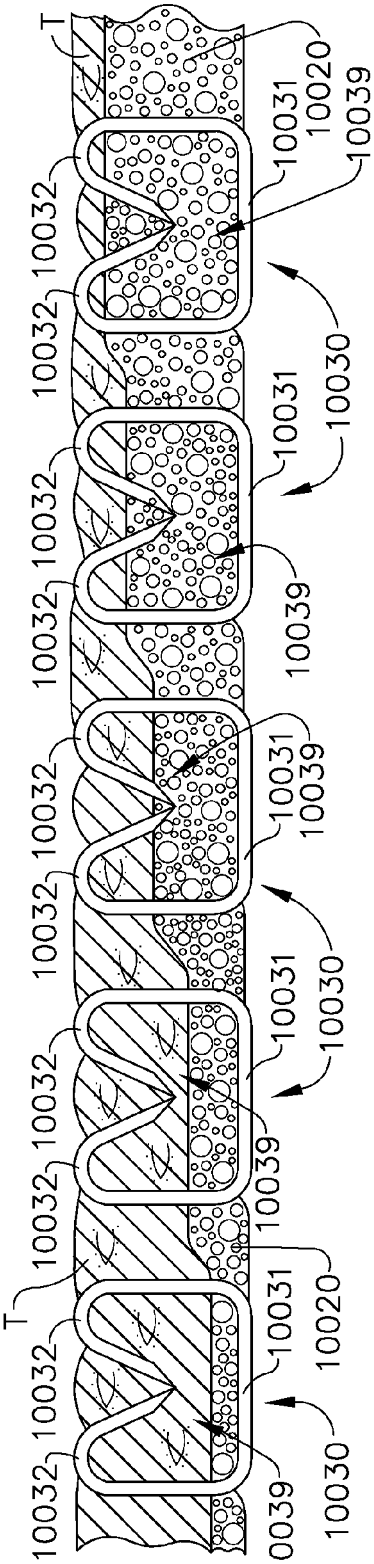

T
10020
10031
10039
10032
10030

FIG. 43

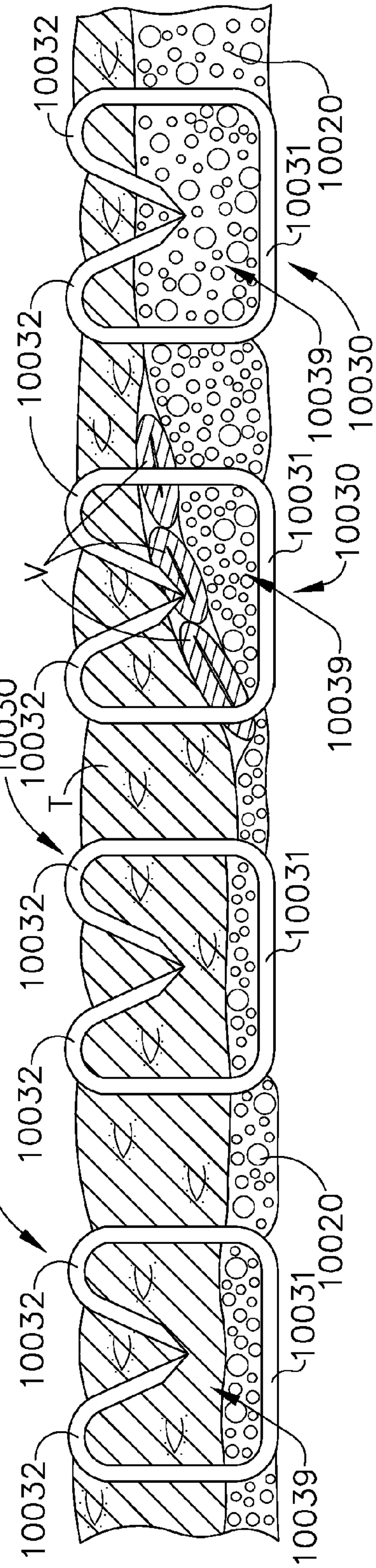

10032
10020
10031
10039
10030
V
T

FIG. 44

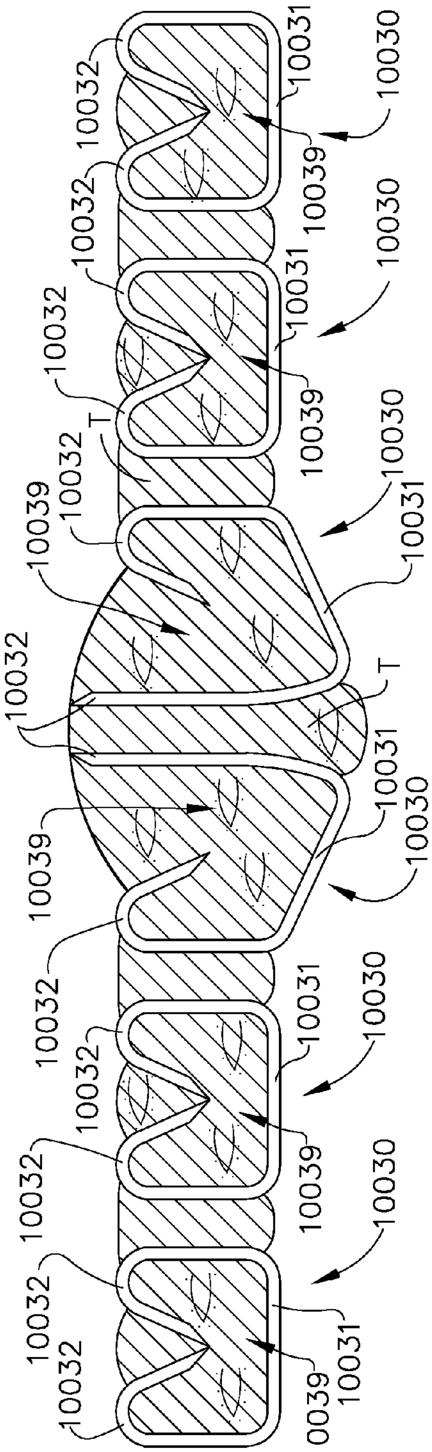


FIG. 45

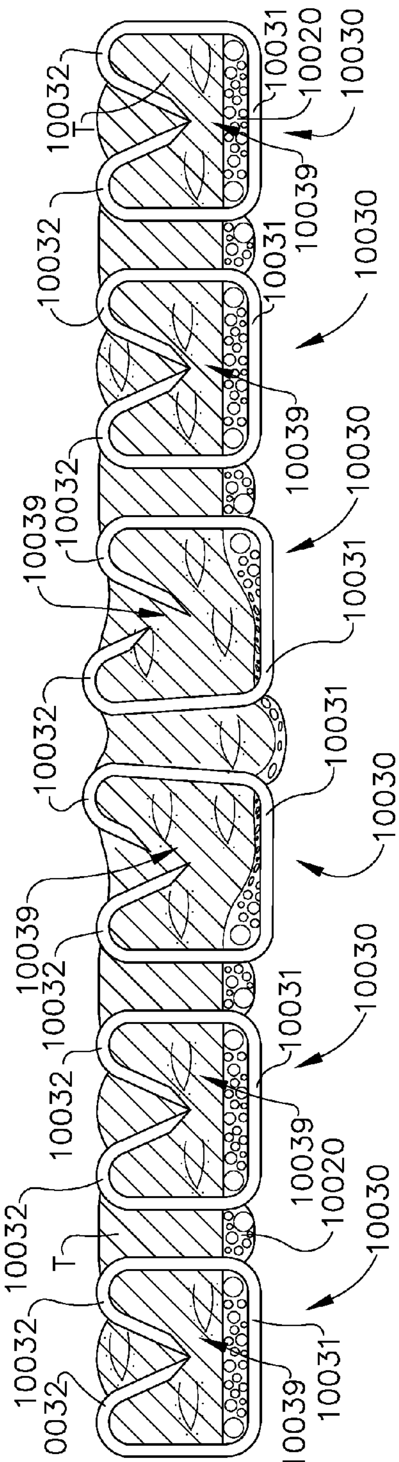


FIG. 46

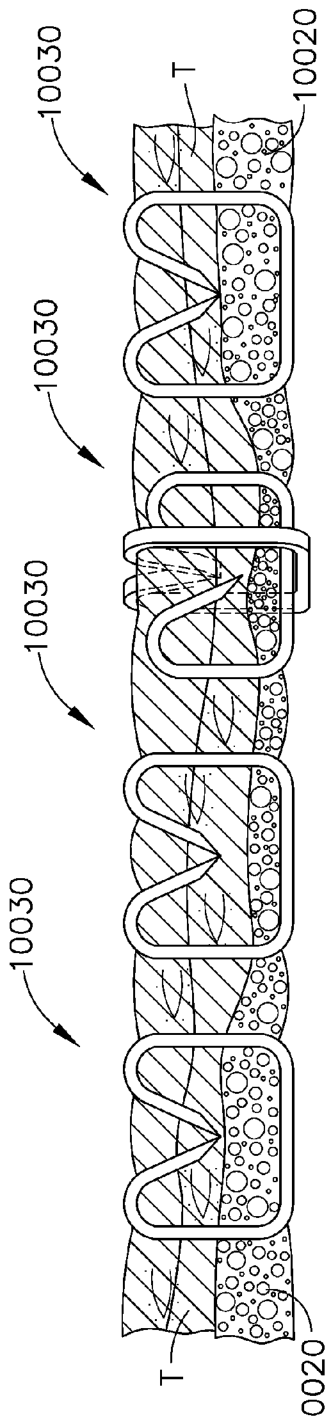


FIG. 47

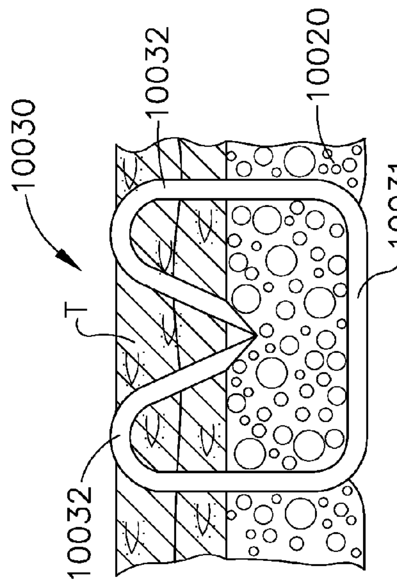


FIG. 49

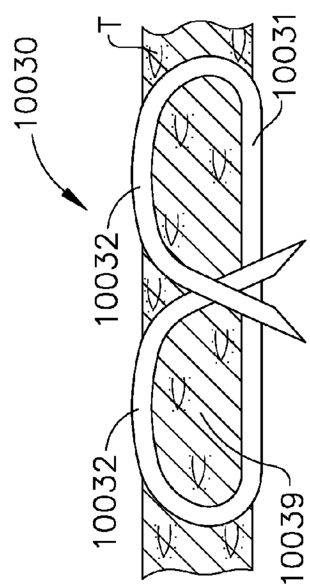


FIG. 48

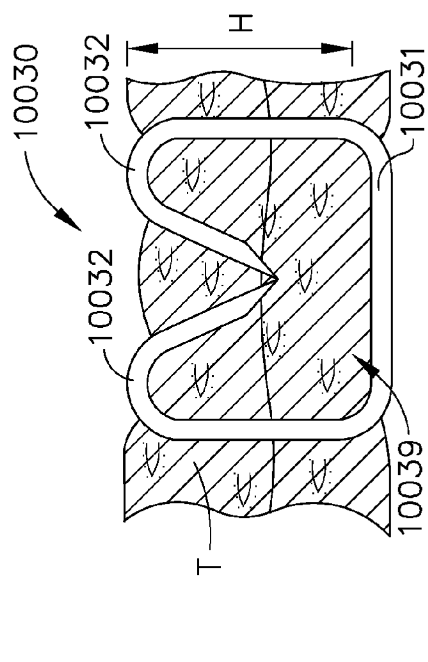


FIG. 50

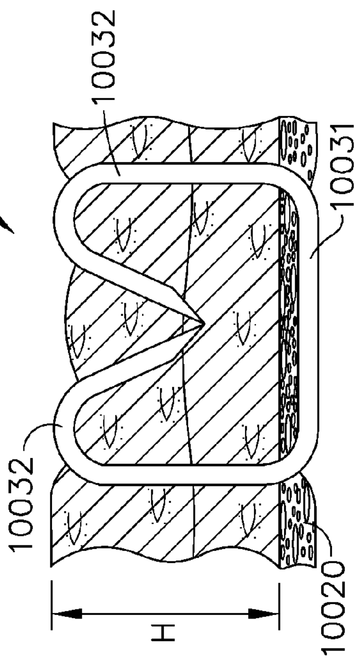


FIG. 51

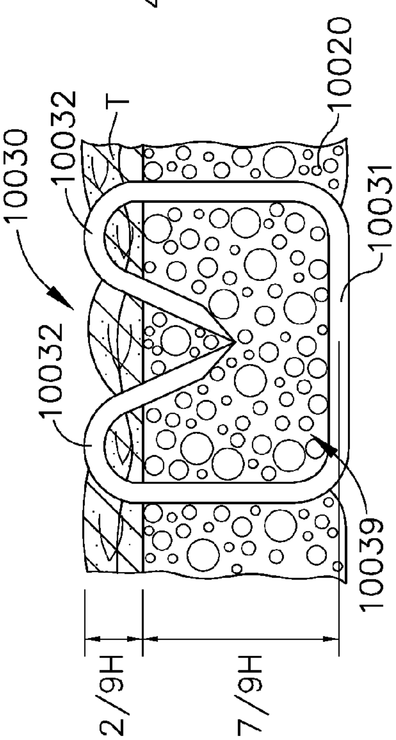


FIG. 52

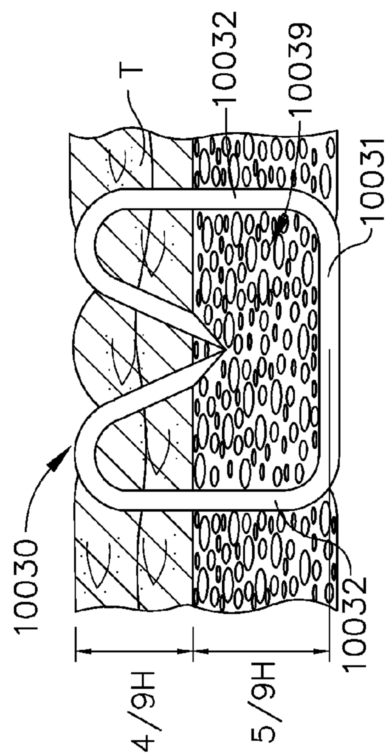


FIG. 53

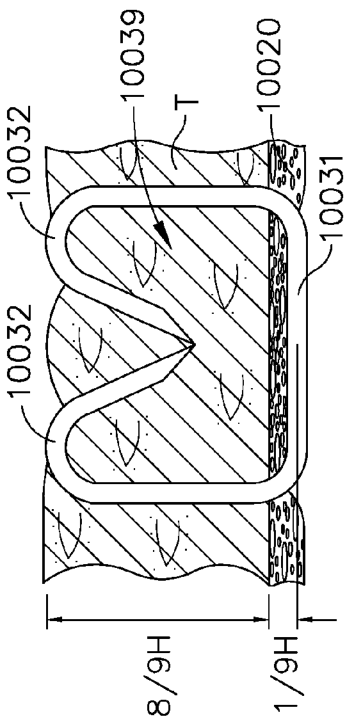


FIG. 55

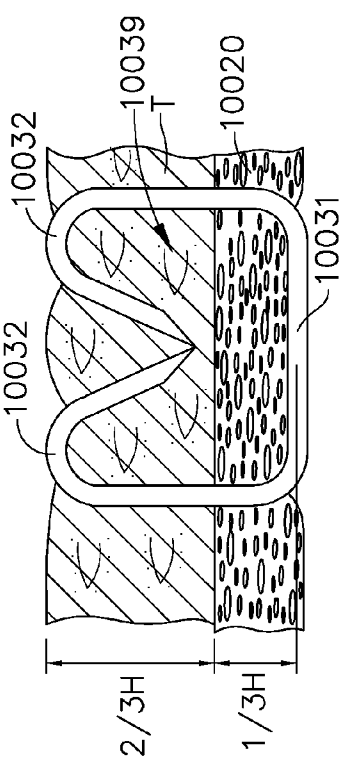


FIG. 54

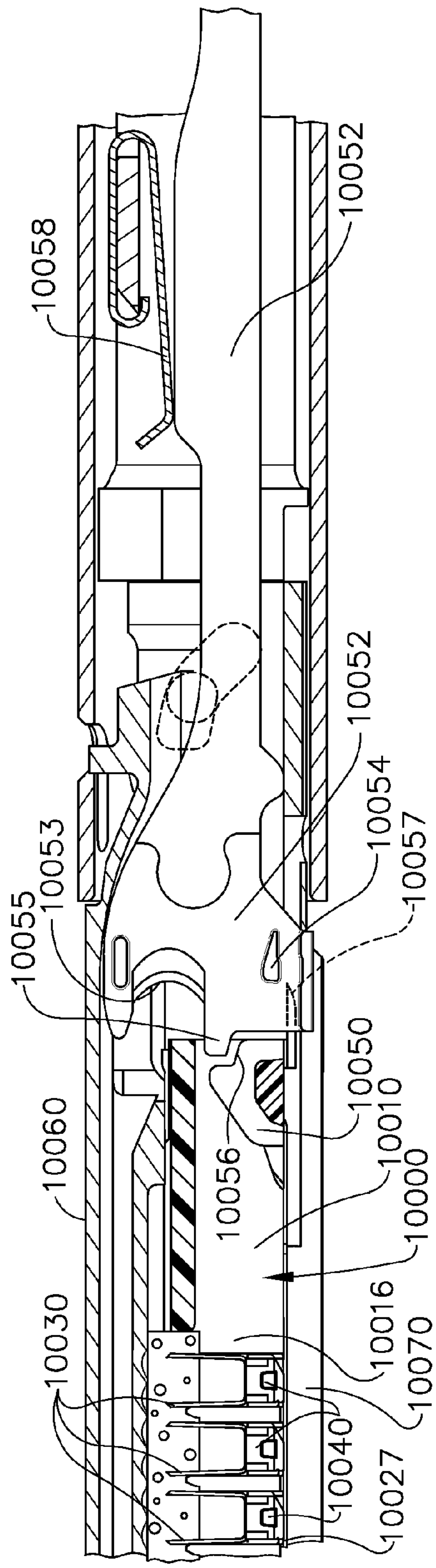


FIG. 56

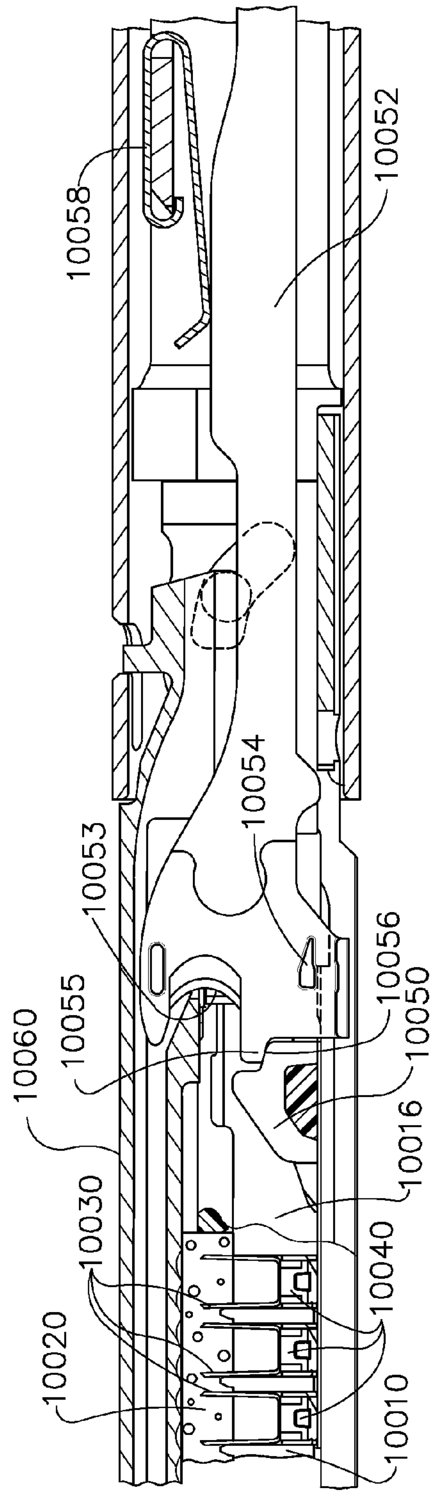

10058
10052
10054
10053
10056
10050
10055
10060
10016
10030
10040
10020
10010

FIG. 57

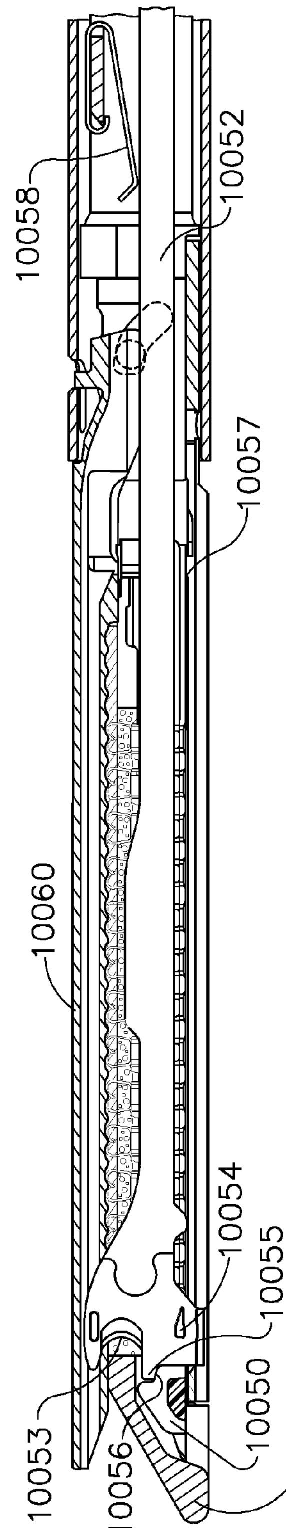

10058
10052
10057
10060
10054
10055
10050
10001
10053
10056

FIG. 58

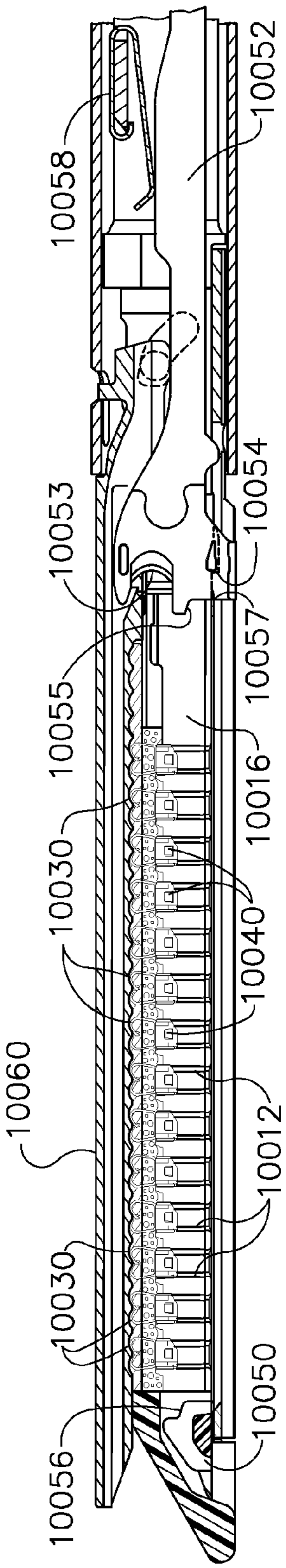

10058
10052
10053
10054
10057
10055
10016
10030
10040
10060
10012
10050
10056

FIG. 59

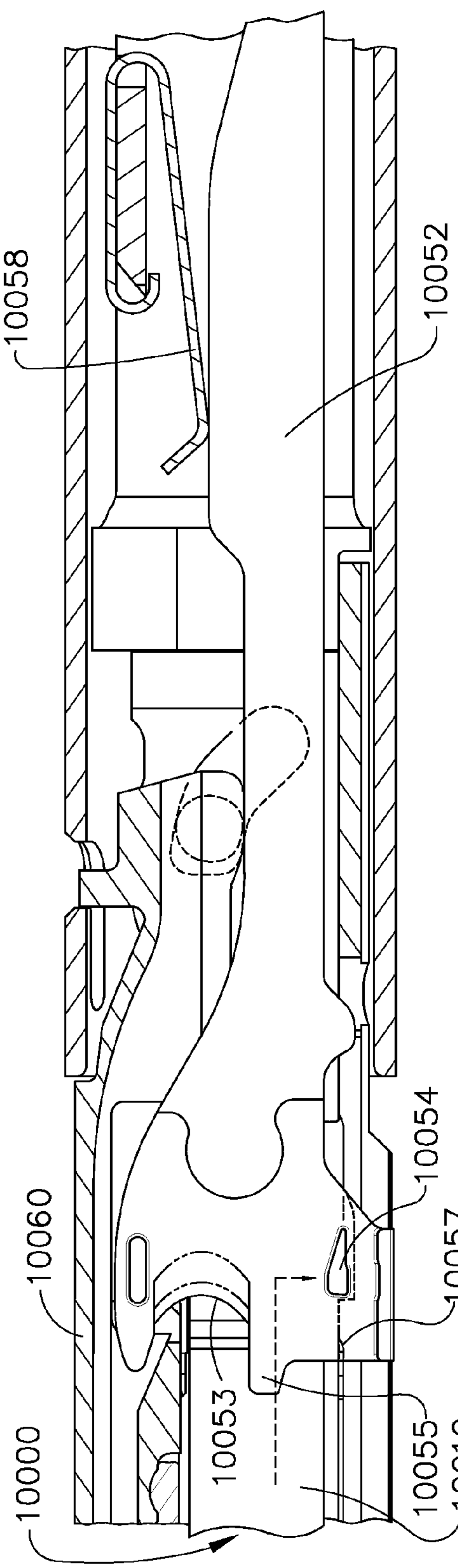

10058
10052
10054
10060
10057
10053
10055
10010
10000

FIG. 60

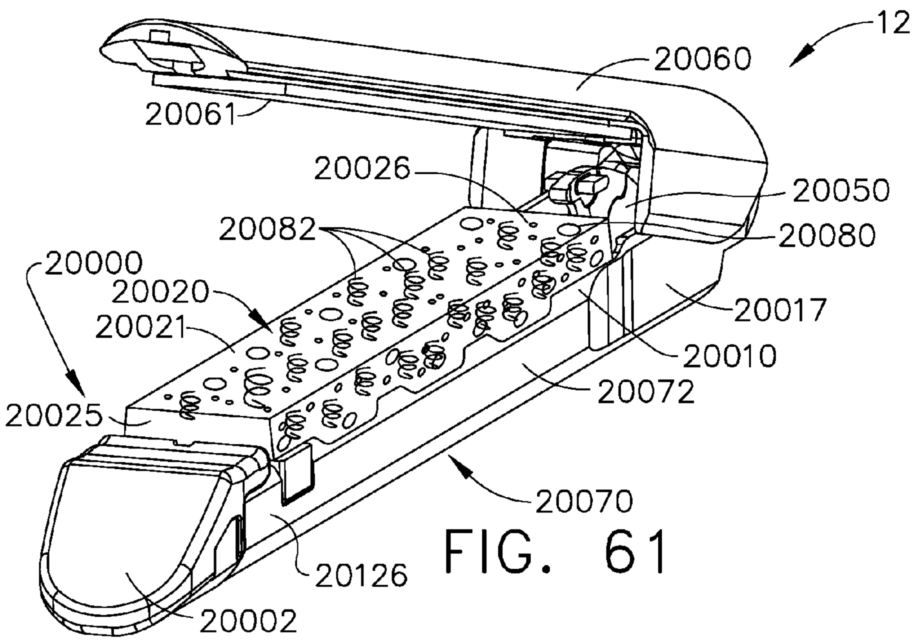

12
20060
20061
20026
20050
20082
20080
20000
20020
20017
20021
20010
20072
20025
20070
20126
20002

FIG. 61

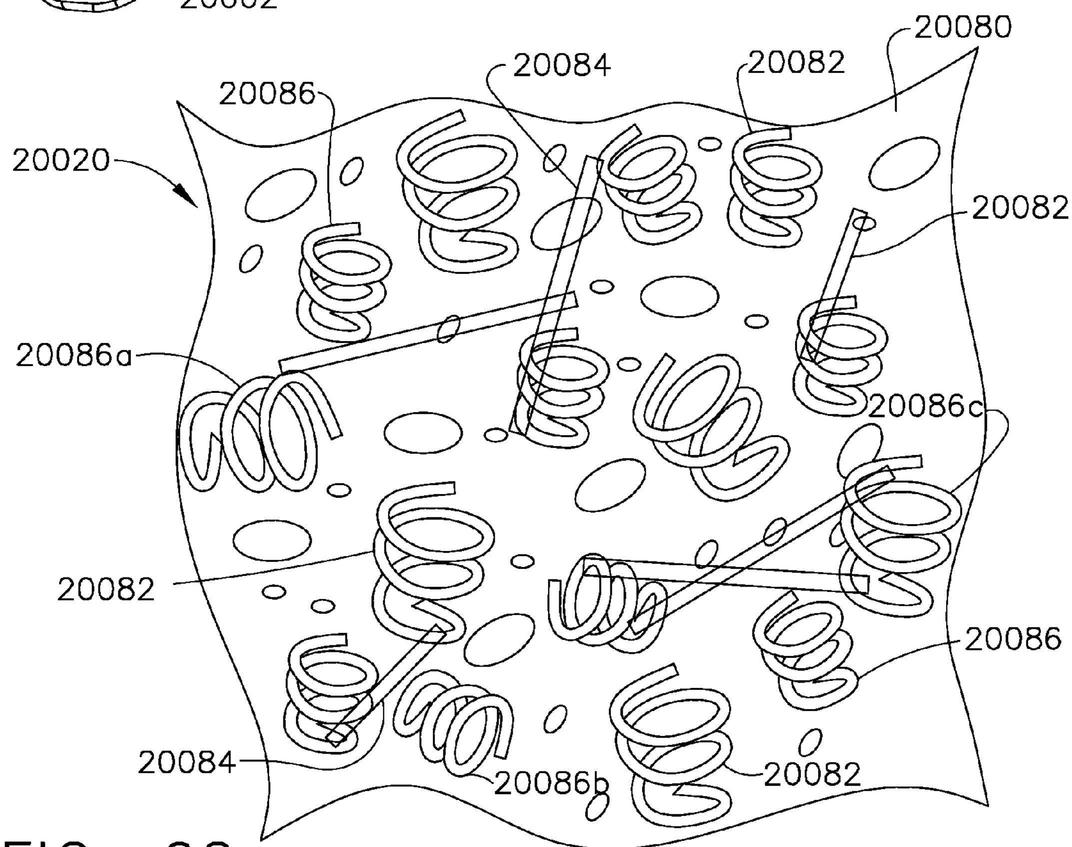

20080
20084
20082
20086
20020
20082
20086a
20086c
20082
20086
20084
20086b
20082

FIG. 62

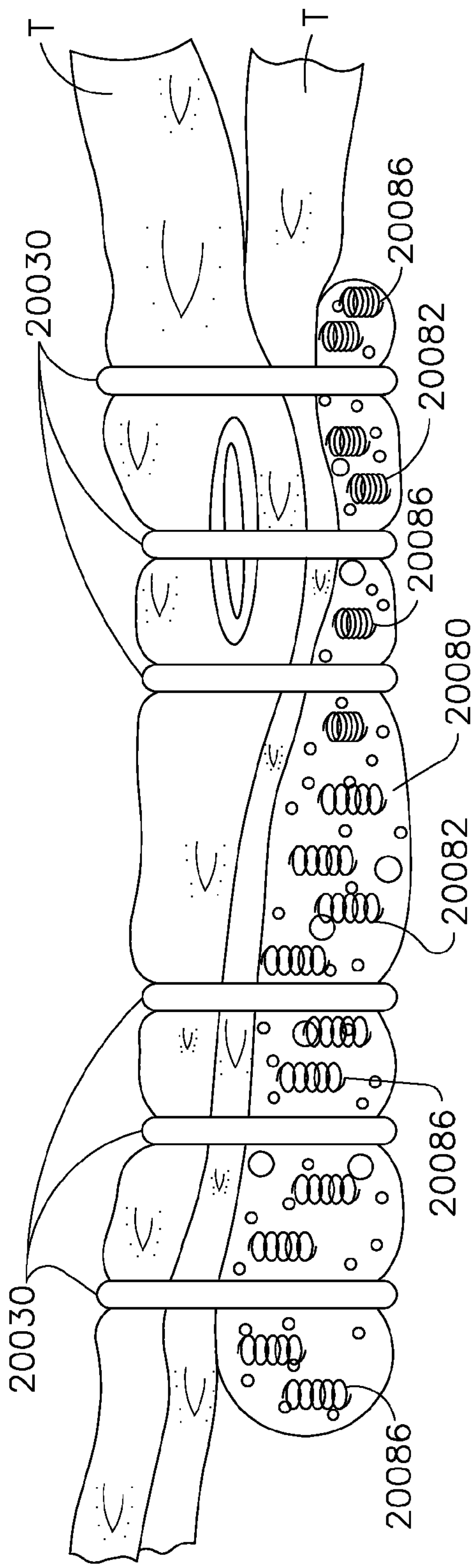


FIG. 63

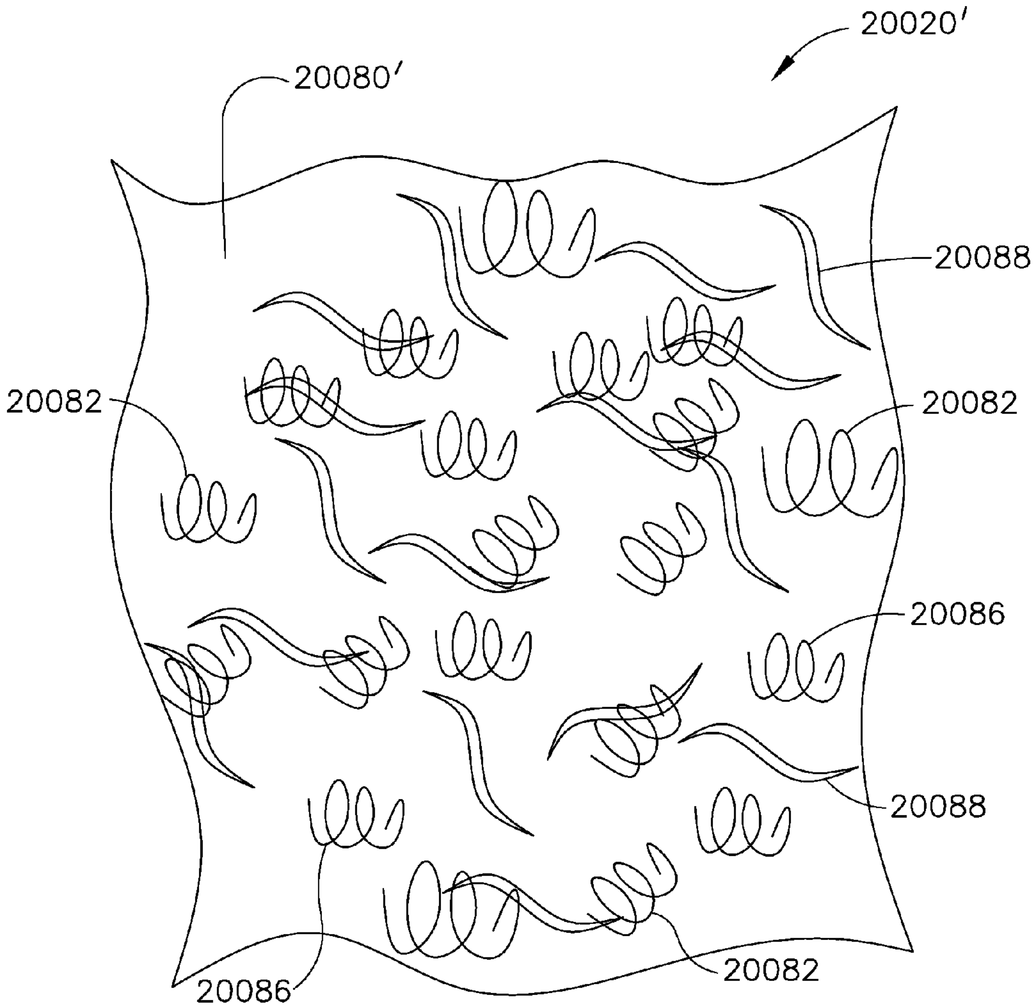


FIG. 64

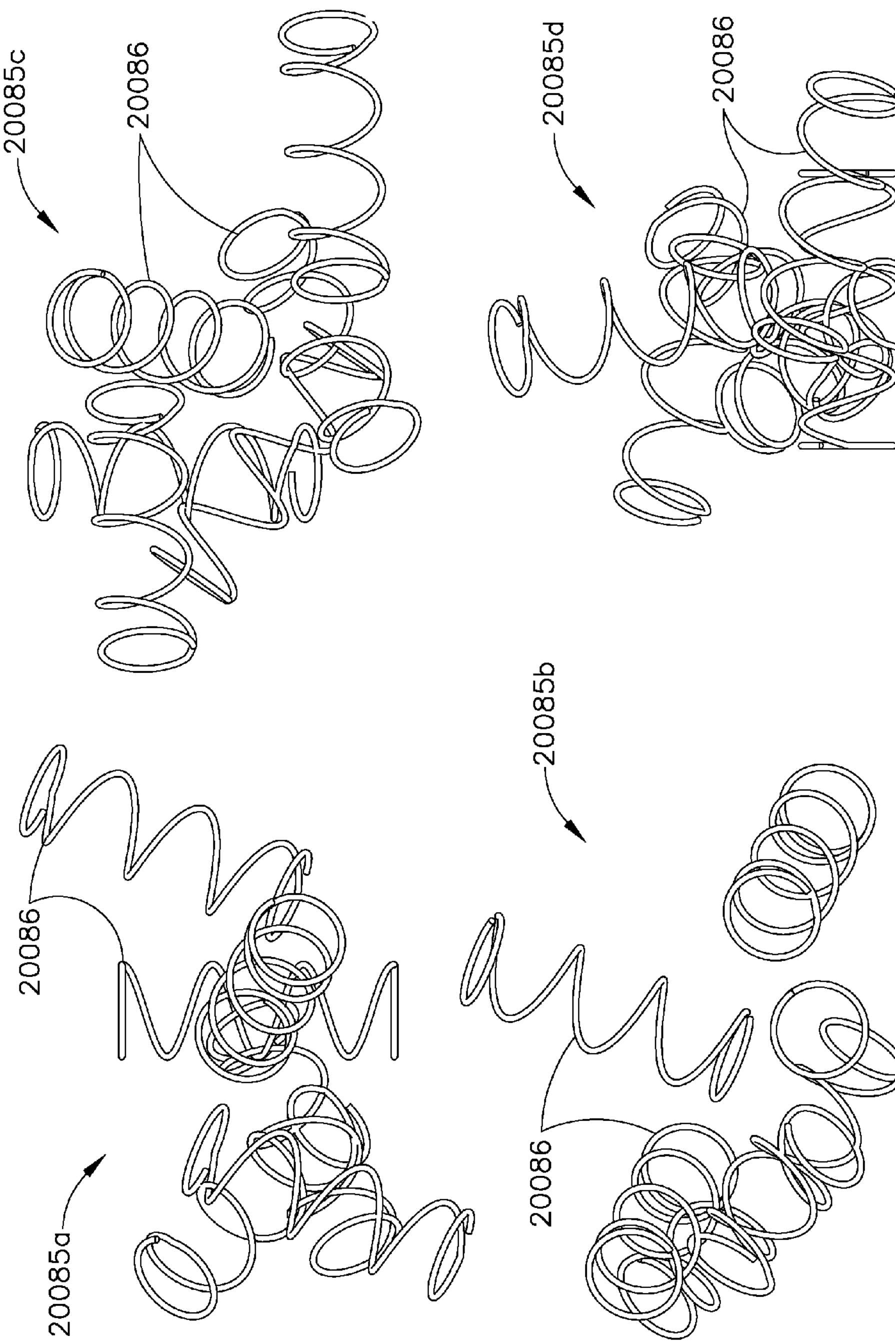


FIG. 65

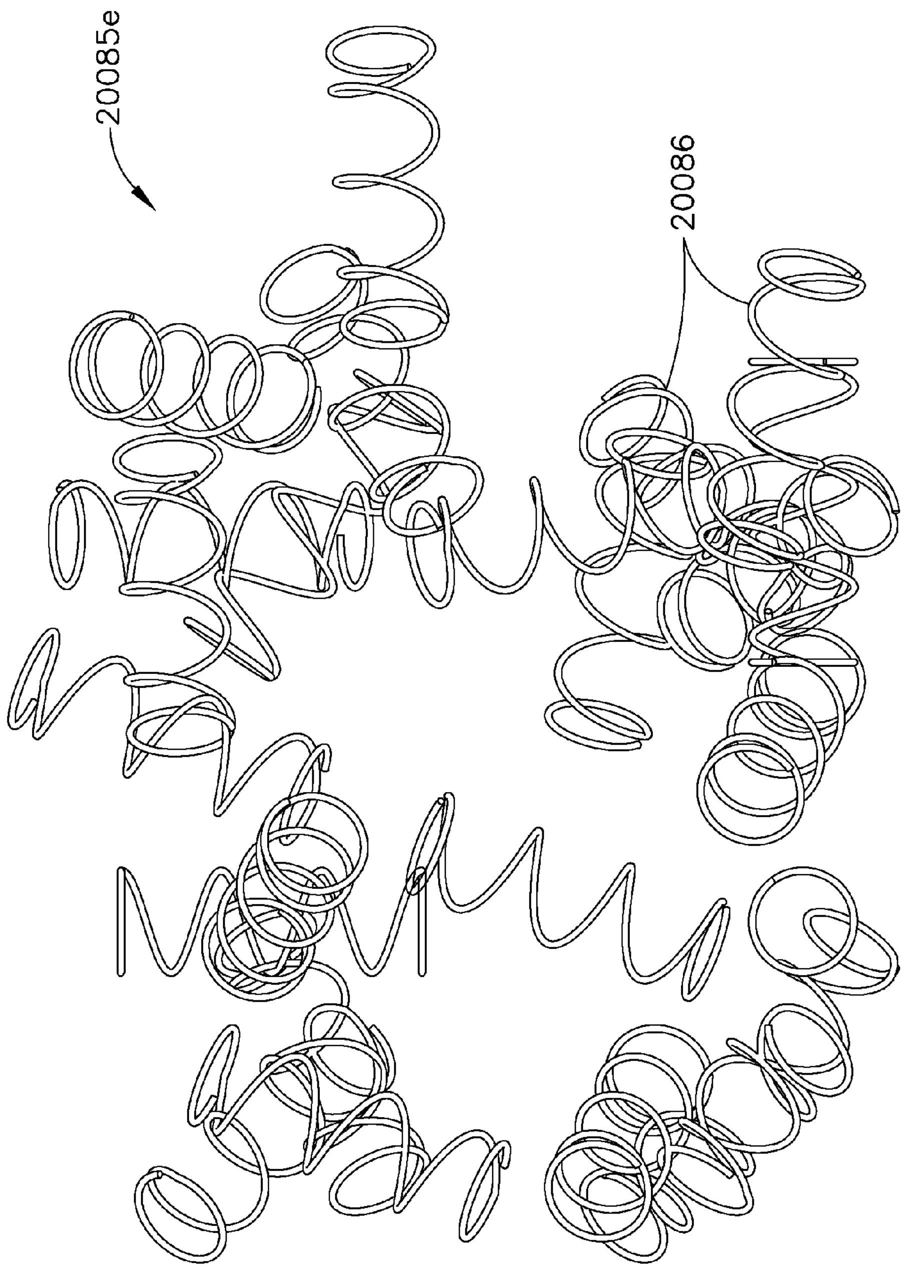


FIG. 66

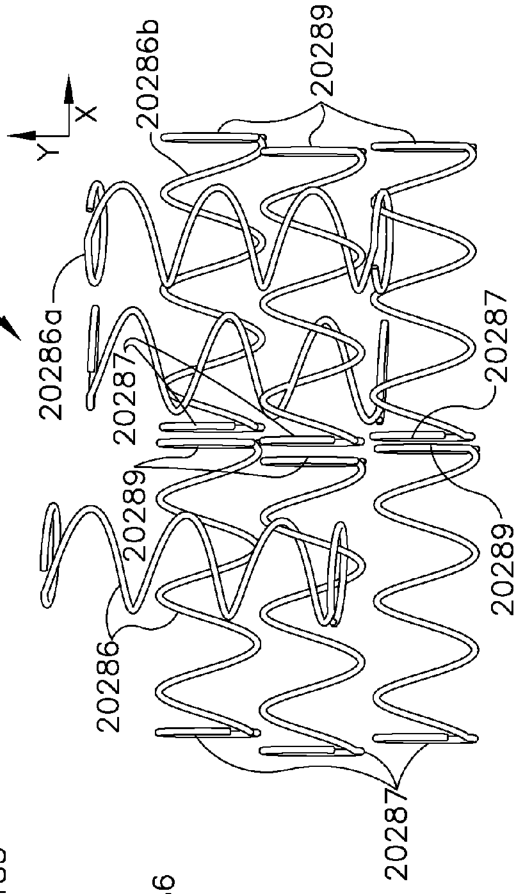


FIG. 68

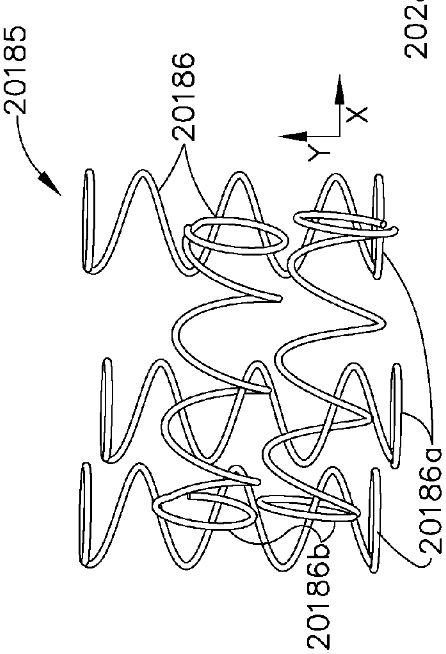


FIG. 67

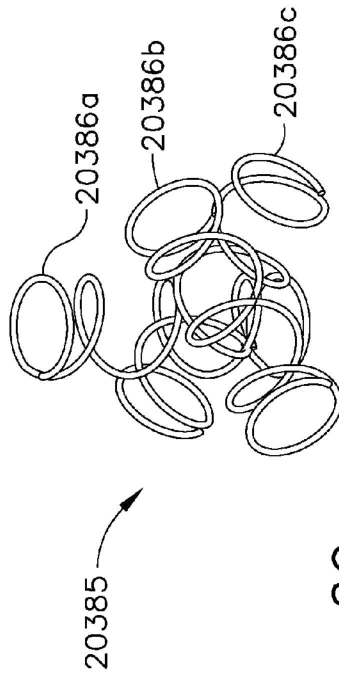


FIG. 69

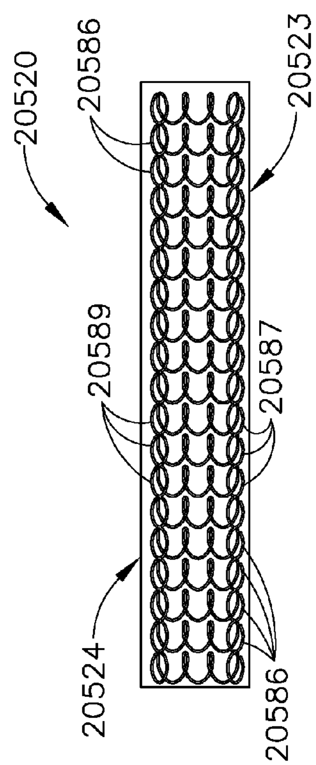


FIG. 70

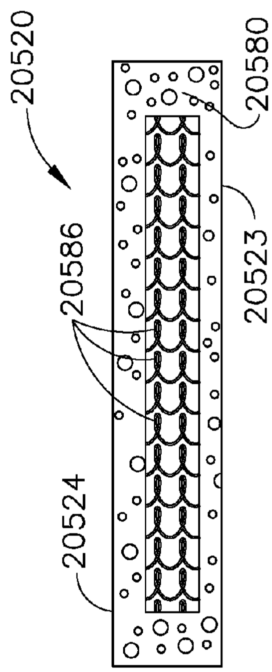


FIG. 70A

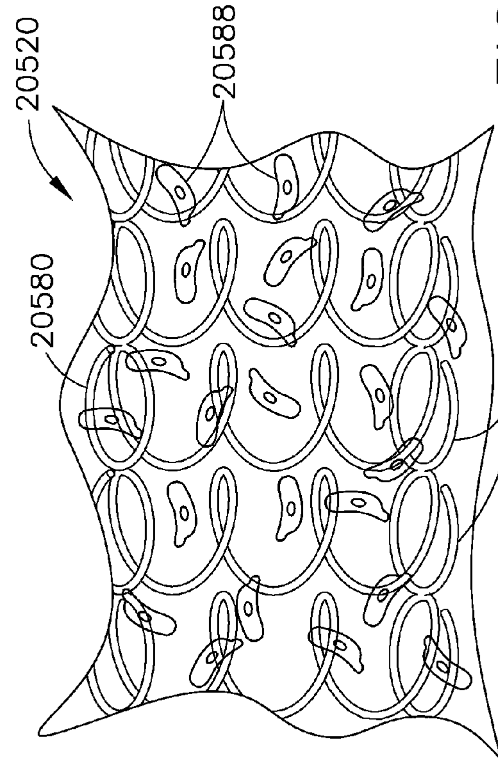


FIG. 70B

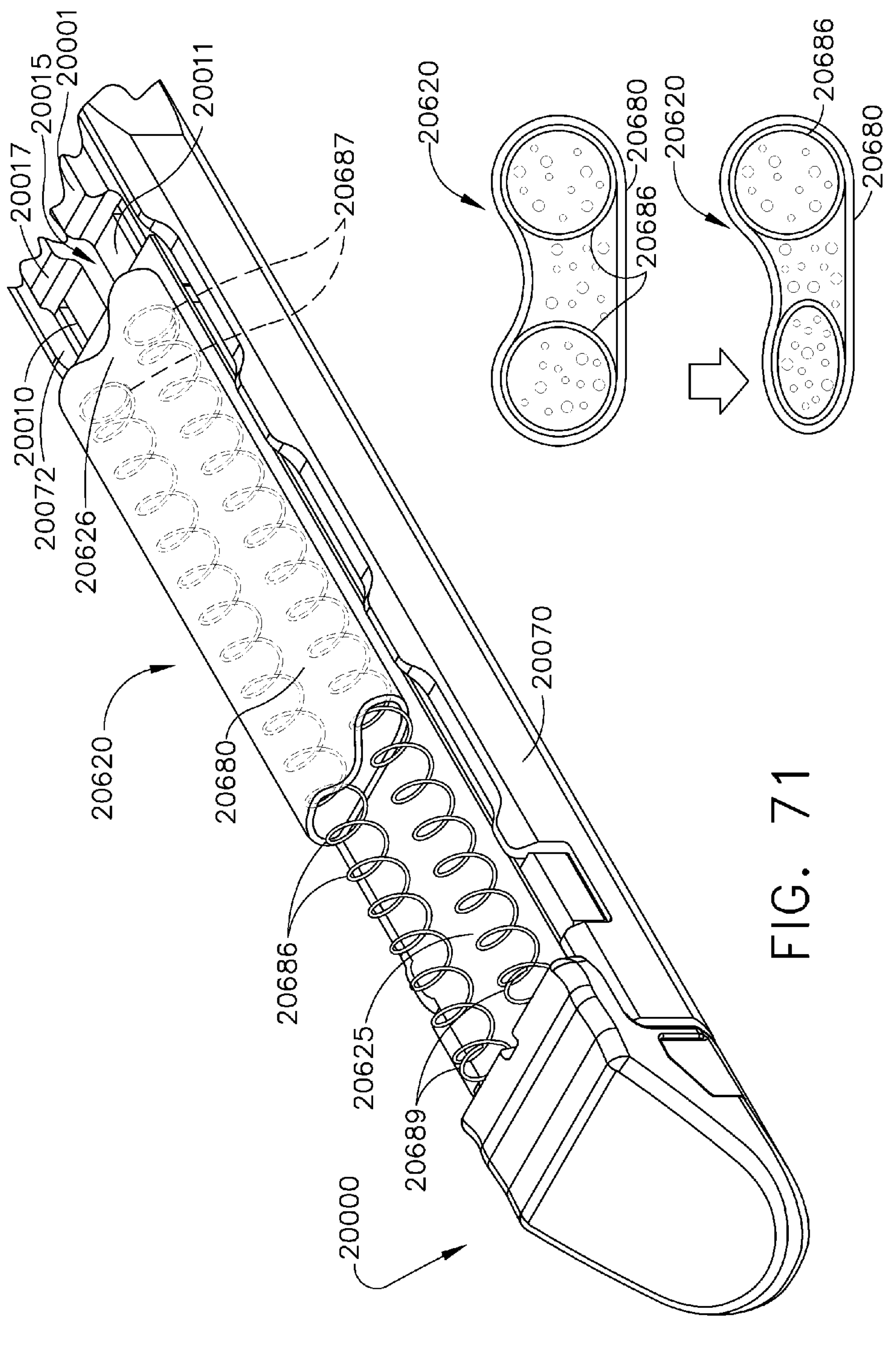

20001
20015
20017
20011
20687
20010
20072
20626
20620
20680
20070
20686
20625
20689
20000
20620
20680
20686
20620
20686
20680

FIG. 71

FIG. 72

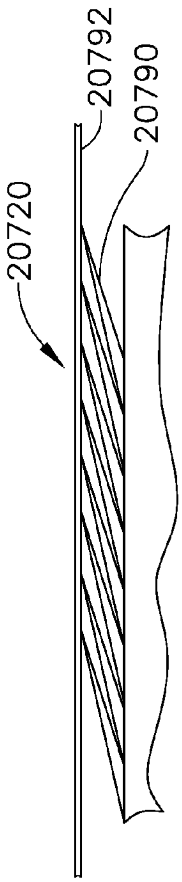


FIG. 73

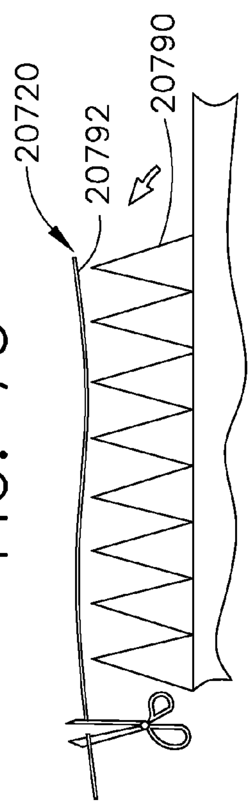


FIG. 74

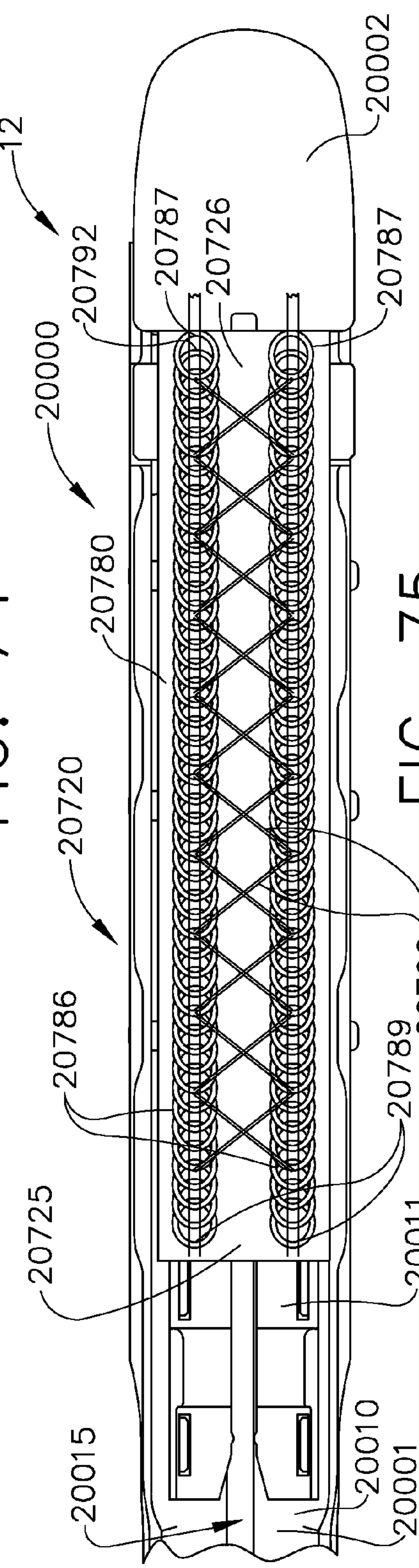


FIG. 75

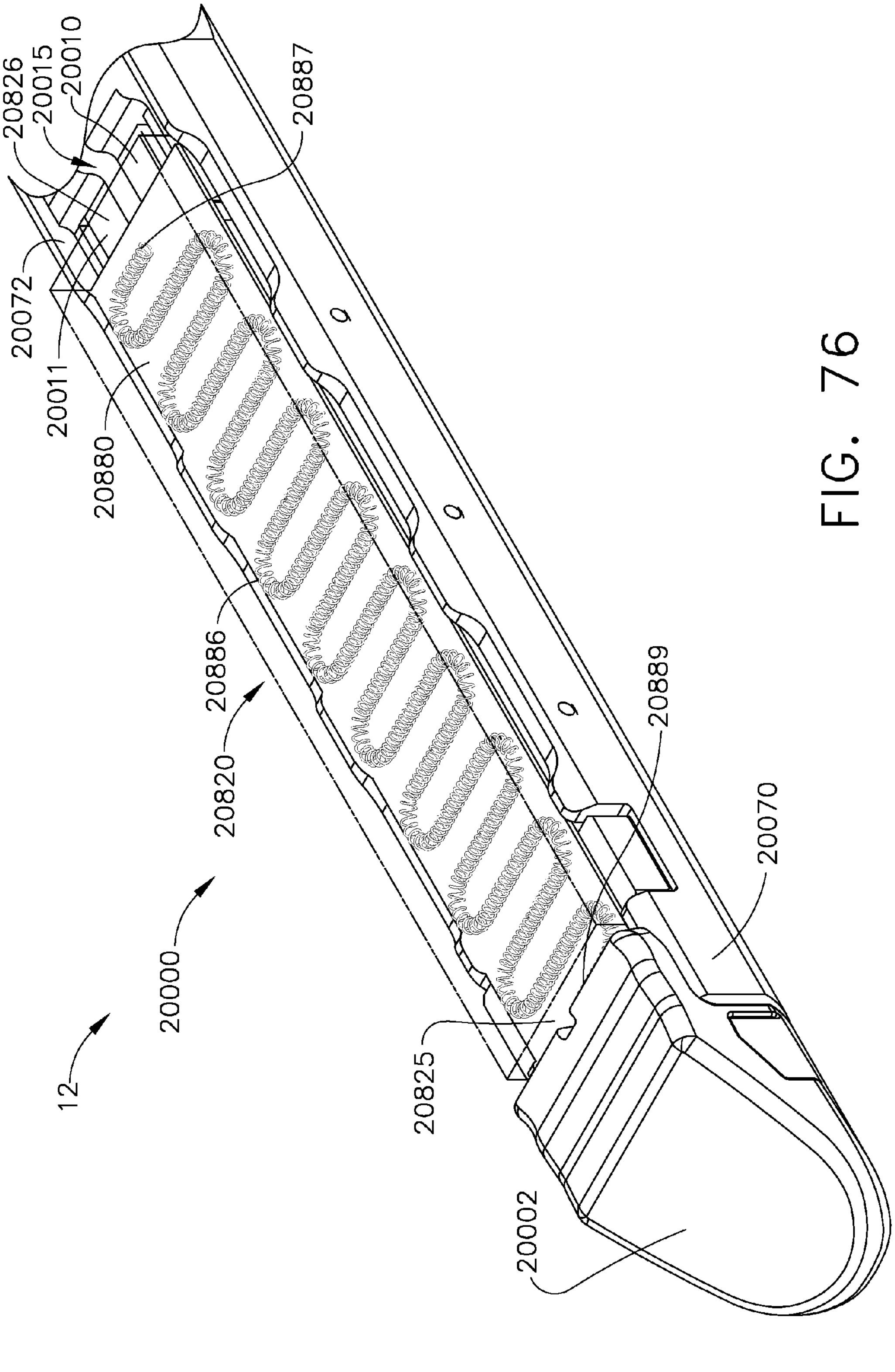

20826
20015
20010
20887
20072
20011
20880
20886
20820
20889
20000
20070
12
20825
20002

FIG. 76

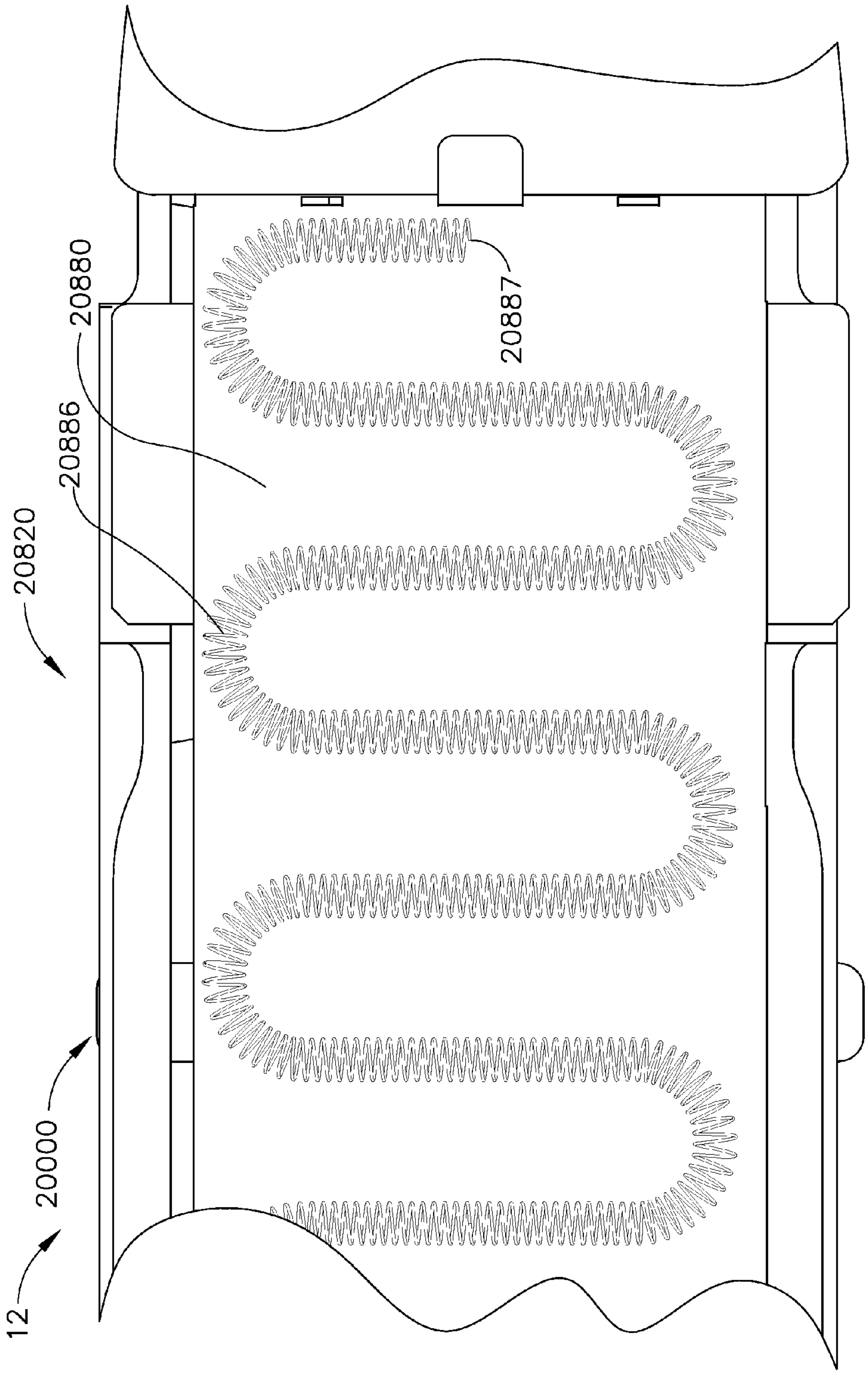


FIG. 77

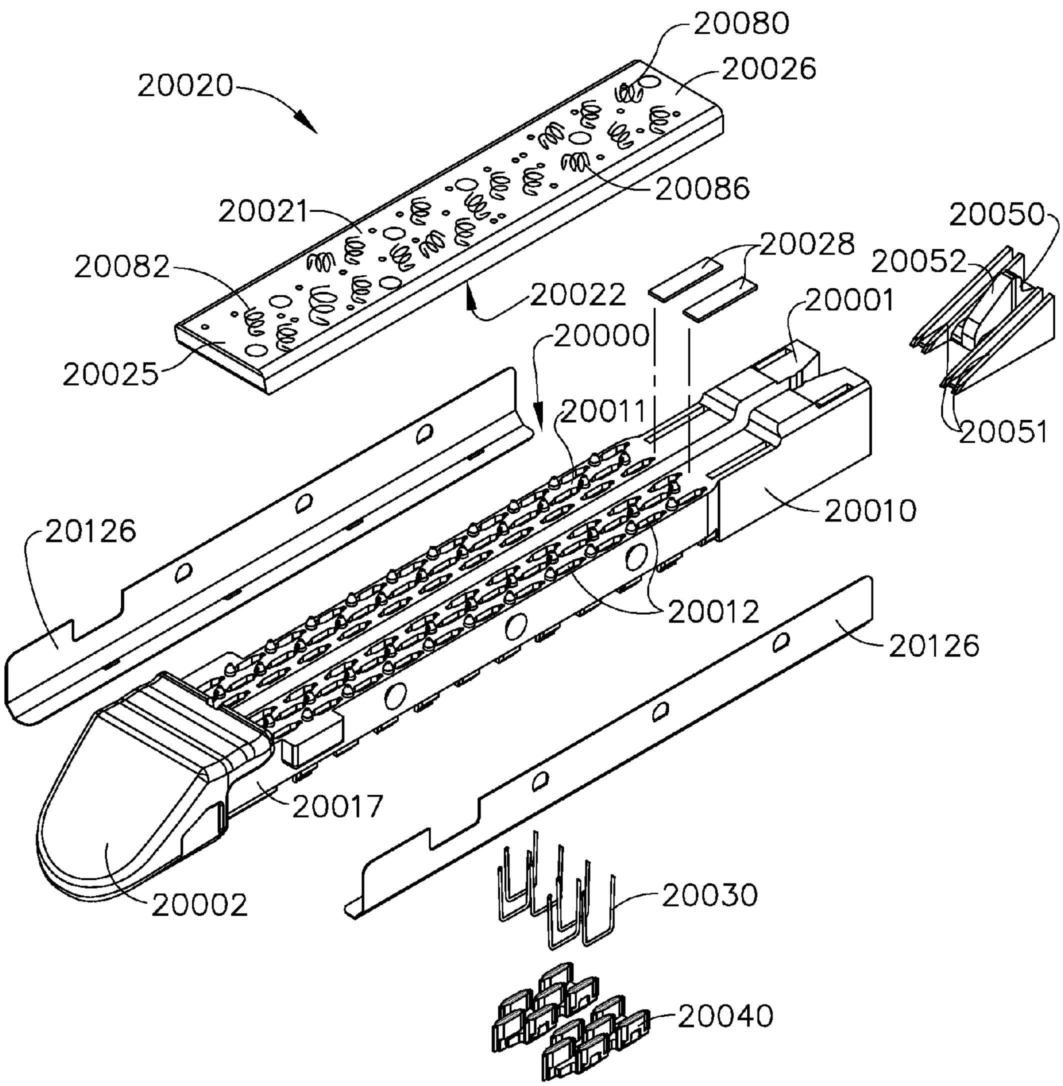

20080
20026
20020
20086
20021
20050
20028
20052
20082
20022
20001
20000
20025
20011
20051
20010
20126
20012
20126
20017
20002
20030
20040

FIG. 78

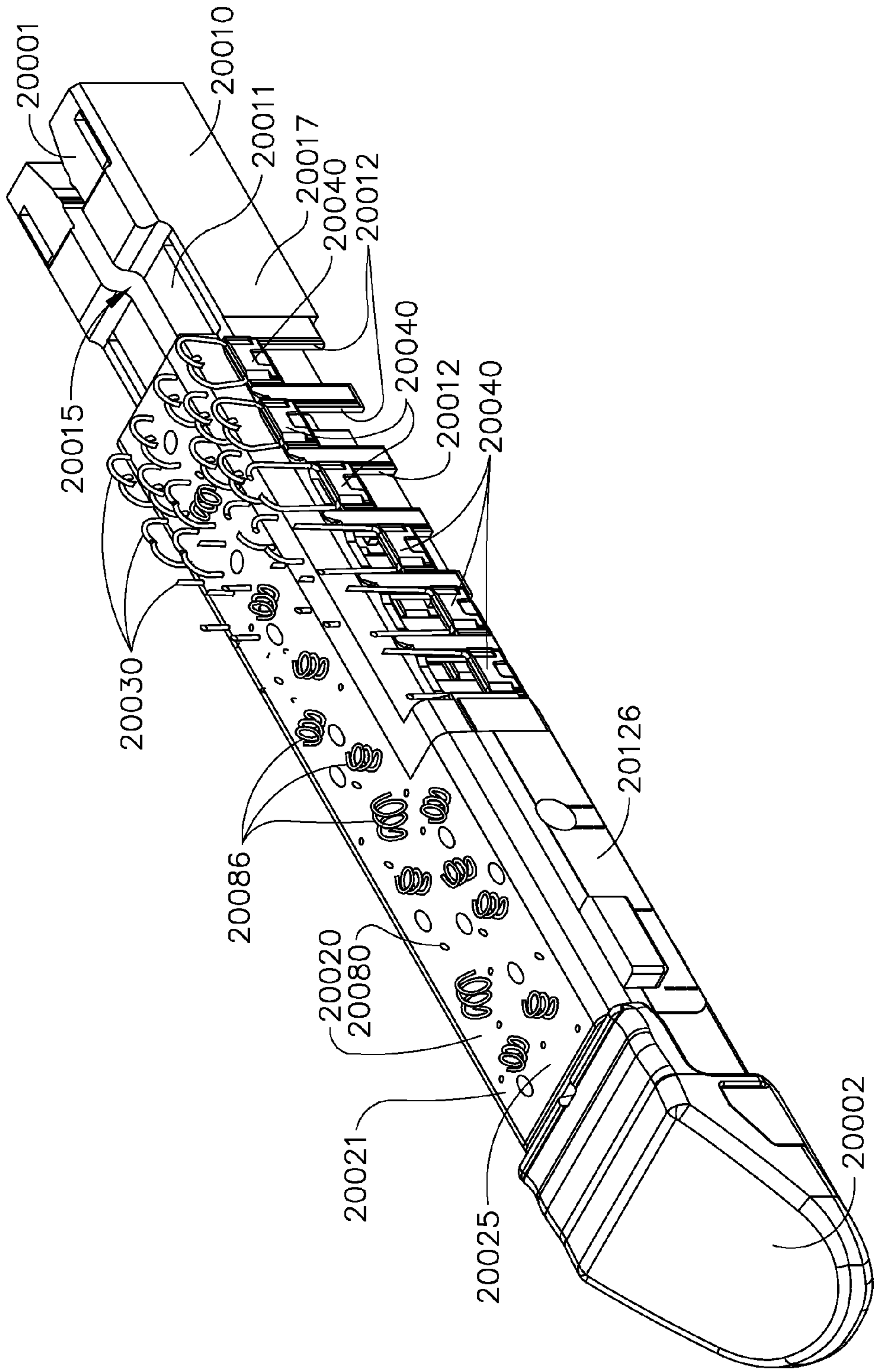

20001
20010
20011
20017
20040
20012
20015
20040
20012
20040
20030
20126
20086
20020
20080
20021
20025
20002

FIG. 79

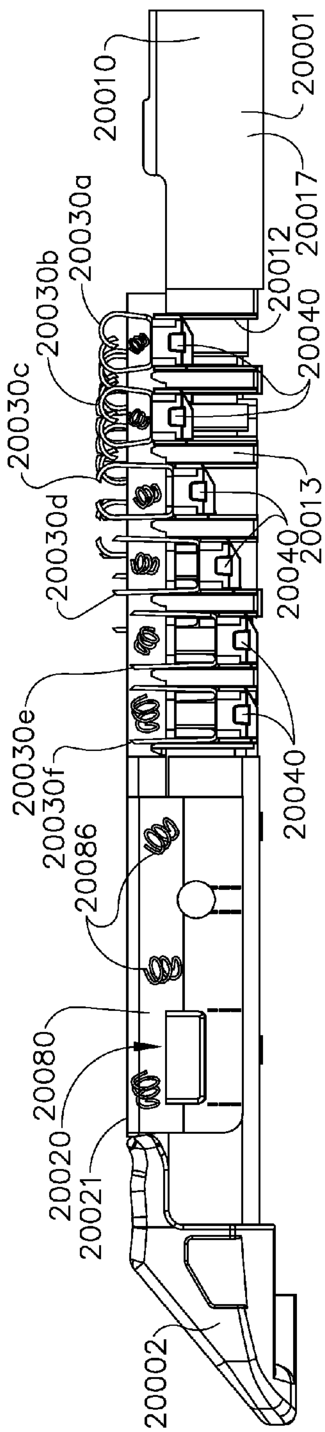

20010
20001
20017
20012
20040
20030a
20030b
20030c
20030d
20013
20030e
20030f
20086
20080
20020
20021
20002

FIG. 80

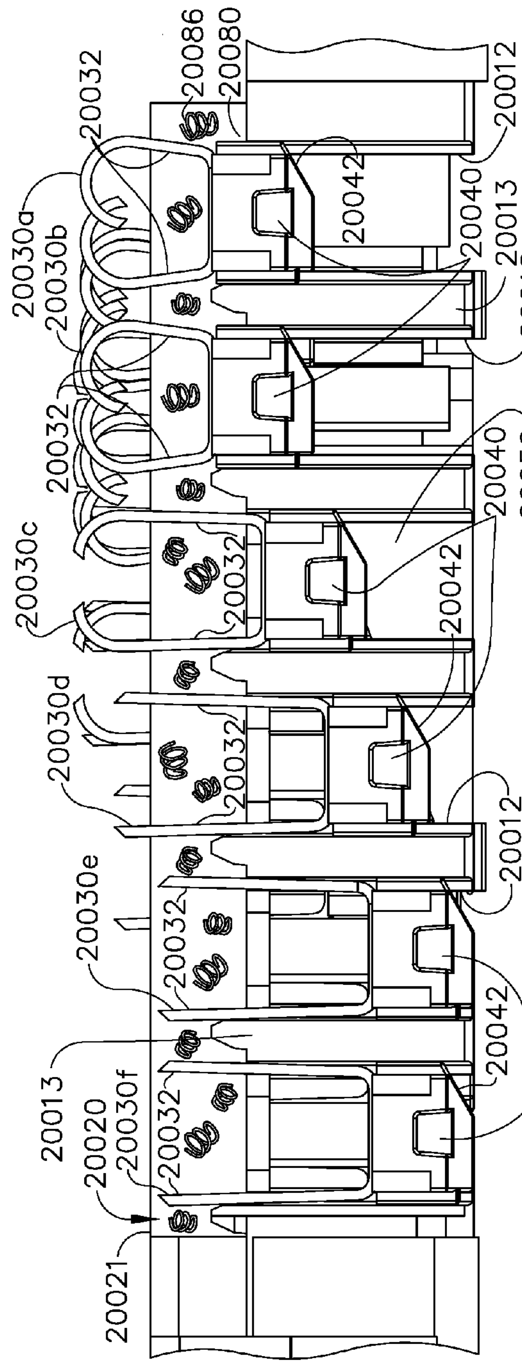

20086
20080
20012
20032
20042
20040
20013
20030a
20030b
20050
20030c
20030d
20030e
20020
20030f
20021

FIG. 81

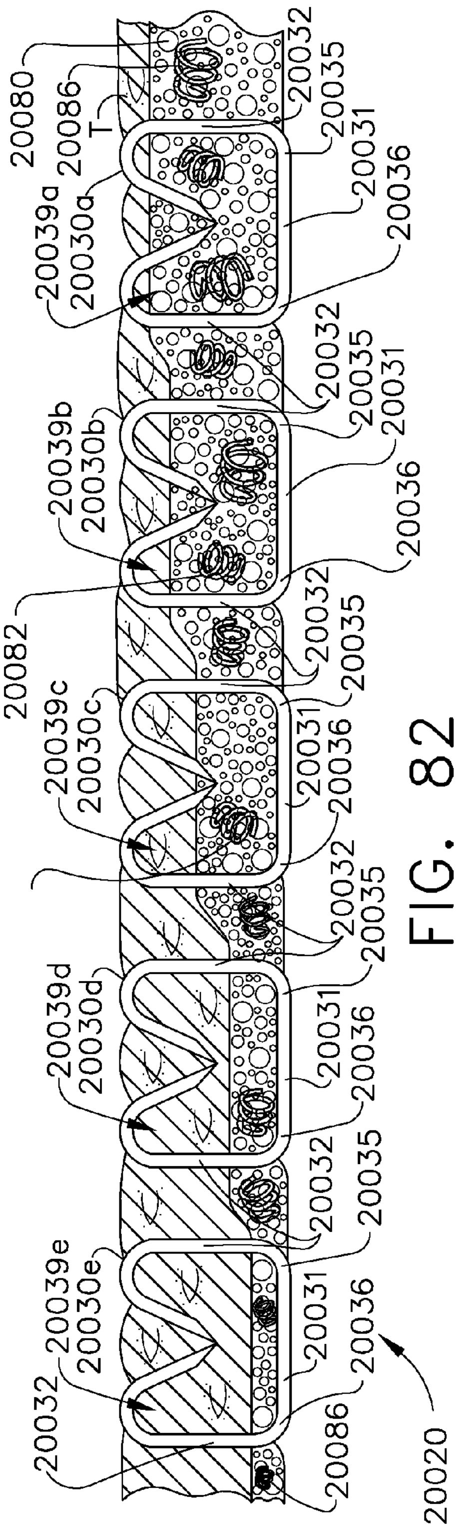

20080
20086
T
20039a
20030a
20032
20035
20031
20036
20039b
20030b
20082
20039c
20030c
20039d
20030d
20039e
20030e
20086
20020

FIG. 82

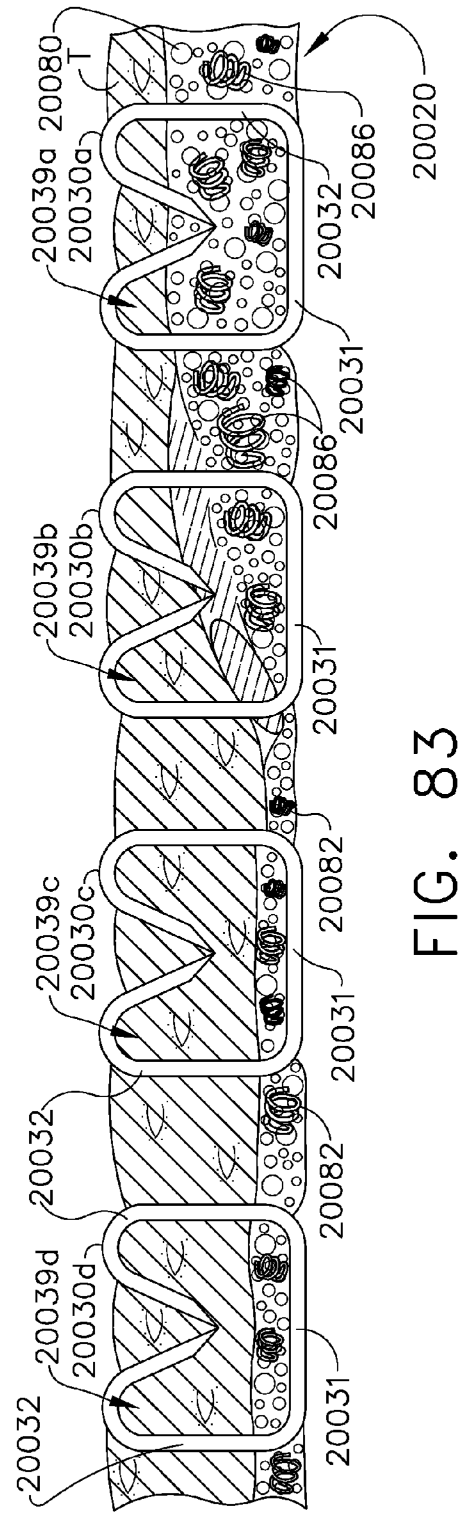

20080
T
20039a
20030a
20032
20086
20020
20031
20039b
20030b
20082
20039c
20030c
20039d
20030d
20032

FIG. 83

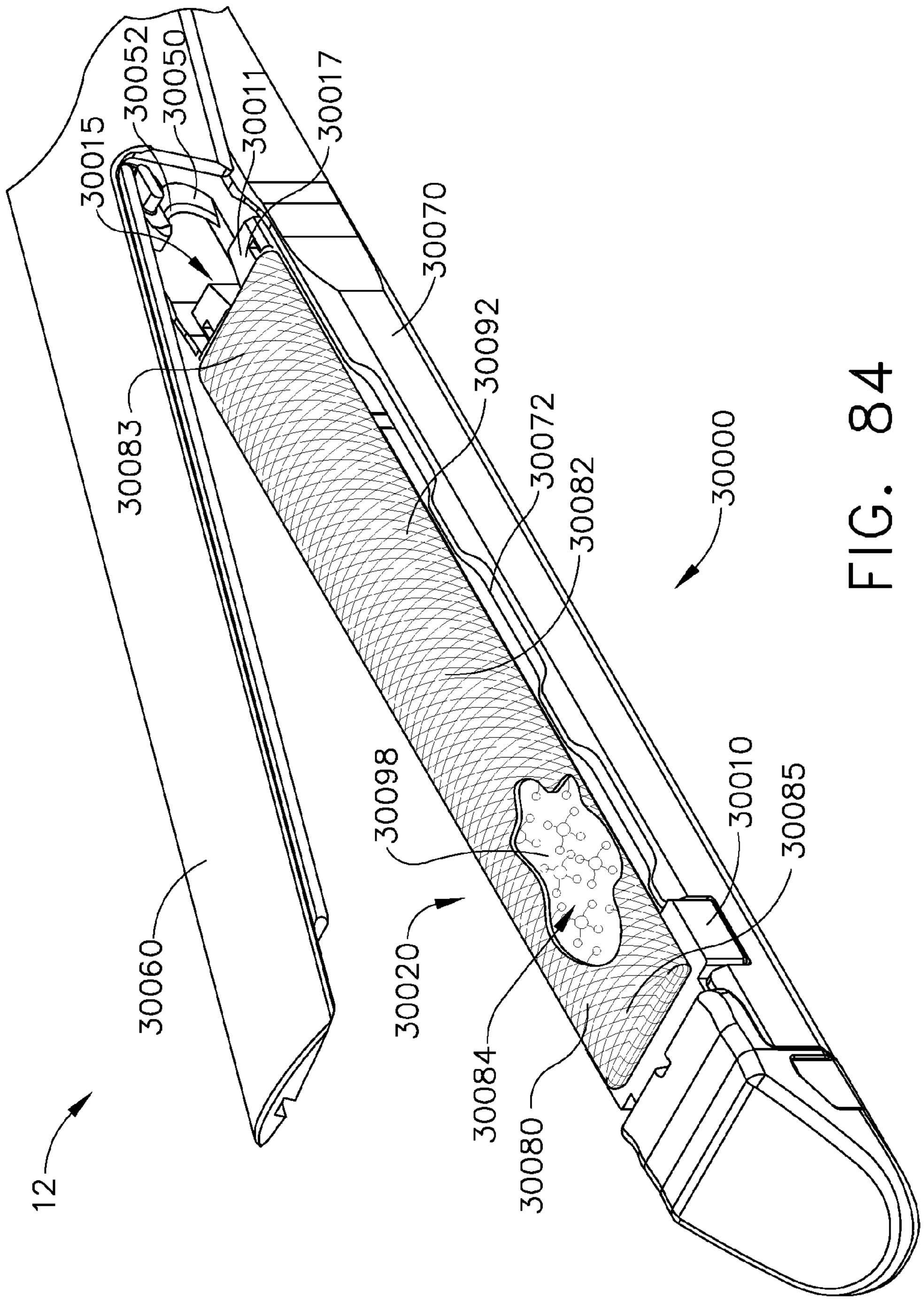

30052
30050
30015
30011
30017
30070
30092
30083
30072
30082
30000
30010
30085
30098
30060
30020
30084
30080
12

FIG. 84

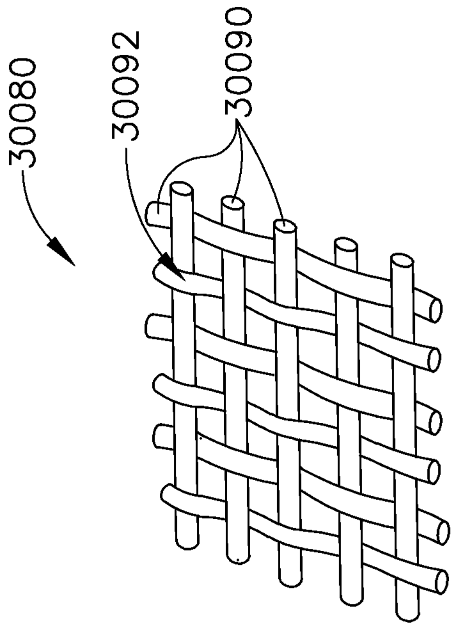

30080
30092
30090

FIG. 86

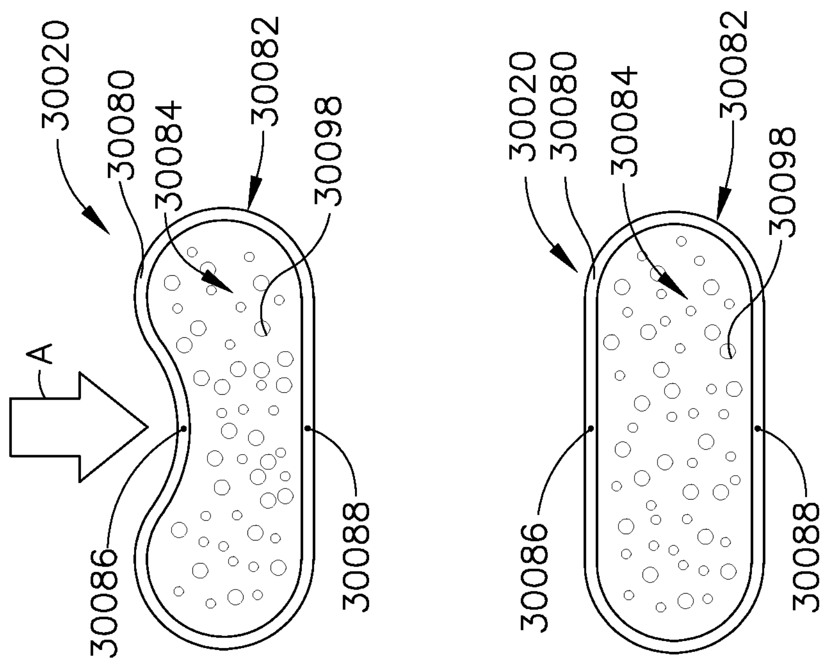

30020
30080
30084
30082
30098
A
30086
30088
30020
30080
30084
30082
30098
30086
30088

FIG. 85

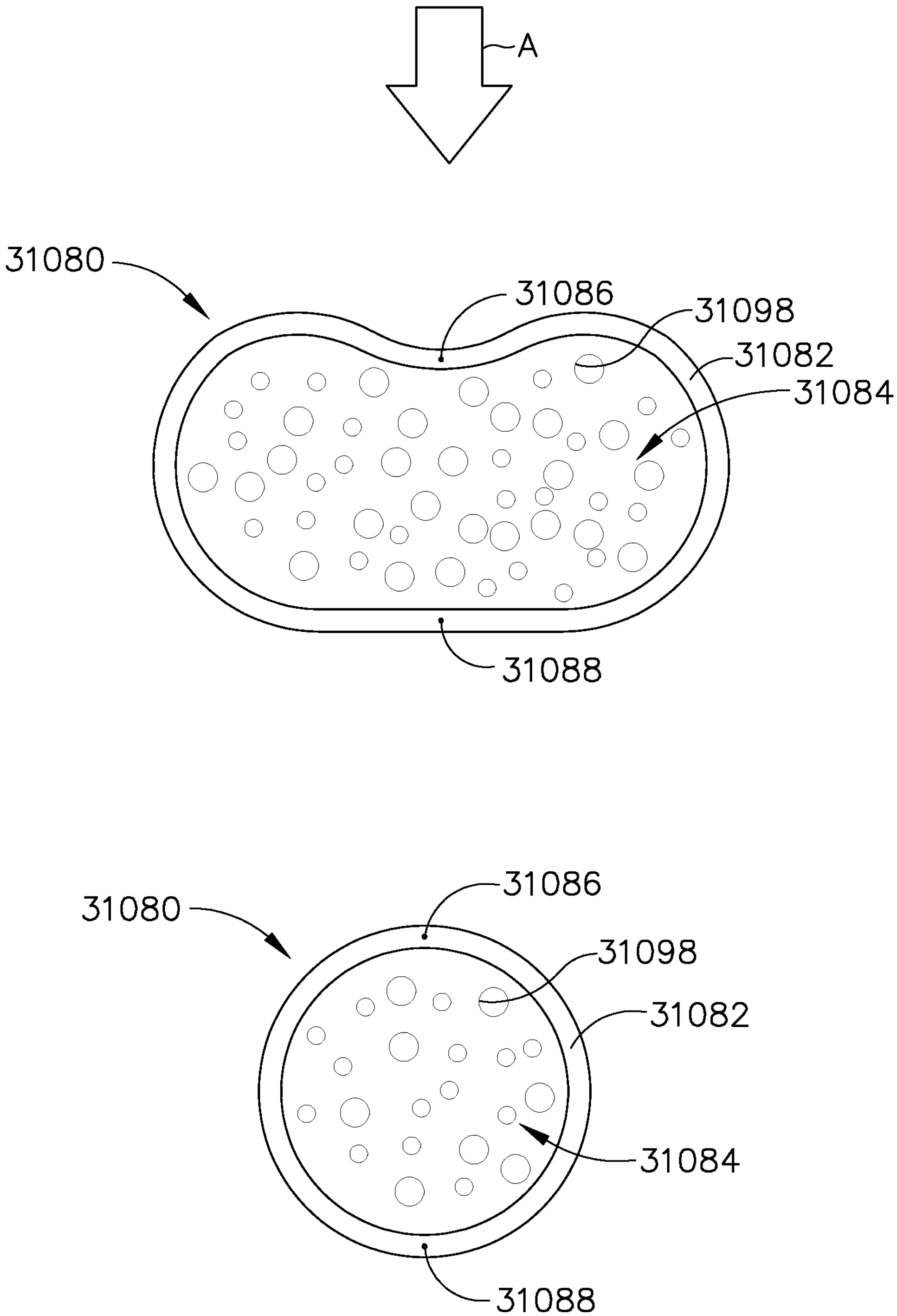

A
31080
31086
31098
31082
31084
31088
31080
31086
31098
31082
31084
31088

FIG. 87

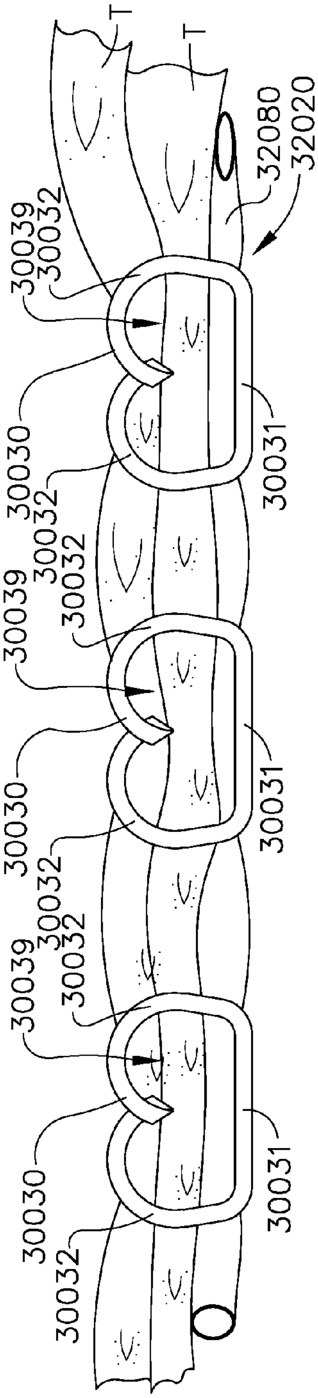

T
T
32080
32020
30039
30032
30030
30032
30031
30039
30032
30030
30032
30031
30039
30032
30030
30032
30031

FIG. 88

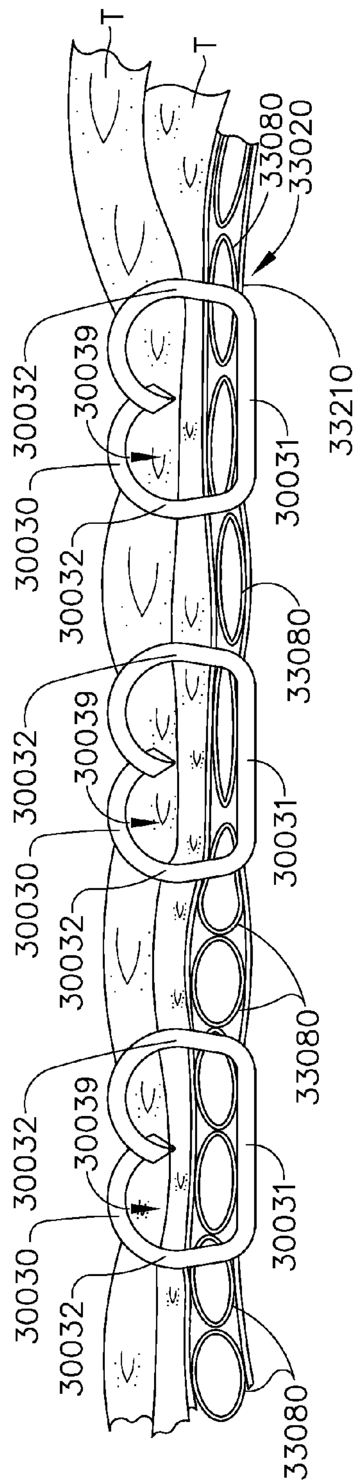

T
T
33080
33020
33210
30032
30039
30030
30032
30031
33080
30032
30039
30030
30032
30031
33080
30032
30039
30030
30032
30031
33080

FIG. 89

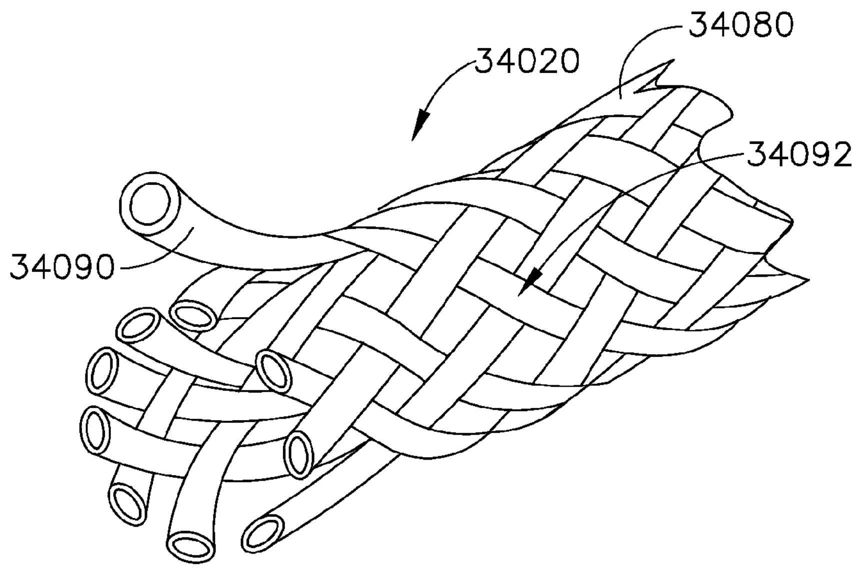


FIG. 90

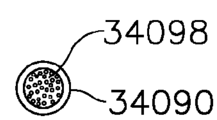


FIG. 91

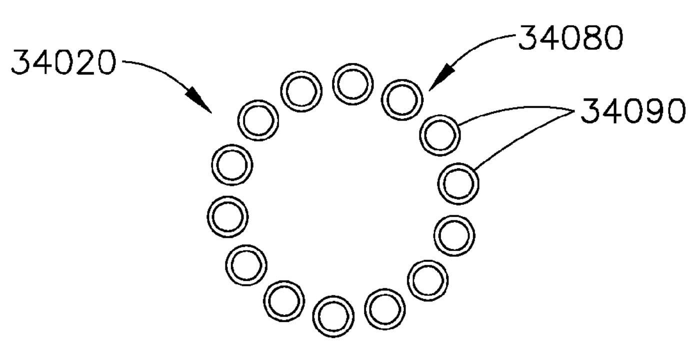


FIG. 92

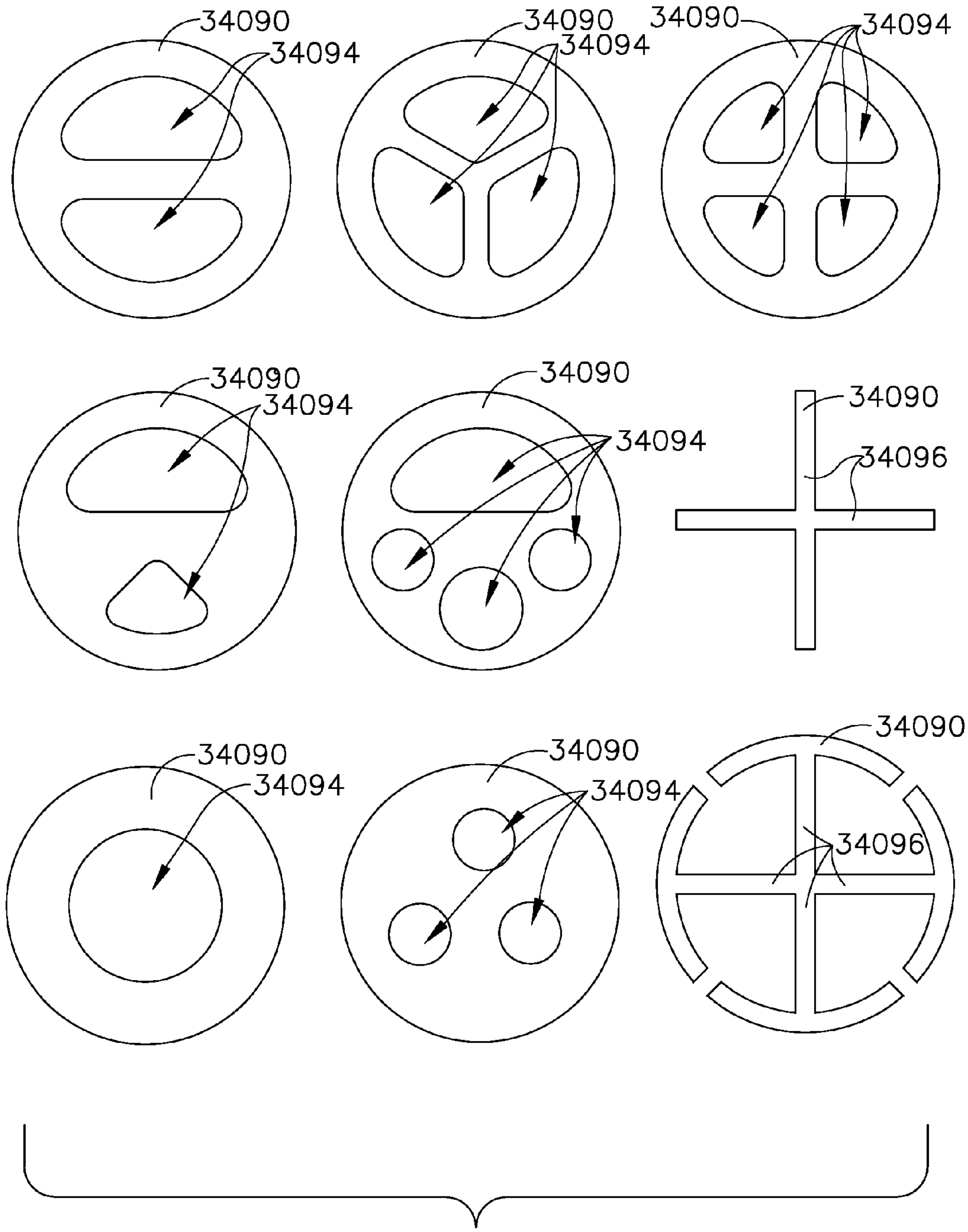

34090
34094
34090
34094
34090
34094
34090
34094
34090
34094
34090
34096
34090
34094
34090
34094
34090
34096

FIG. 93

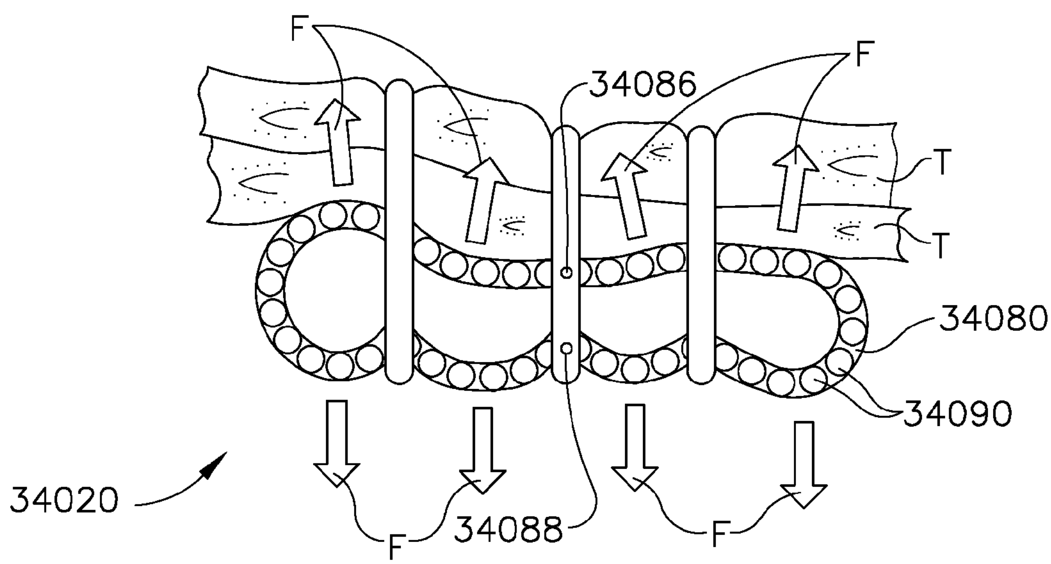


FIG.94

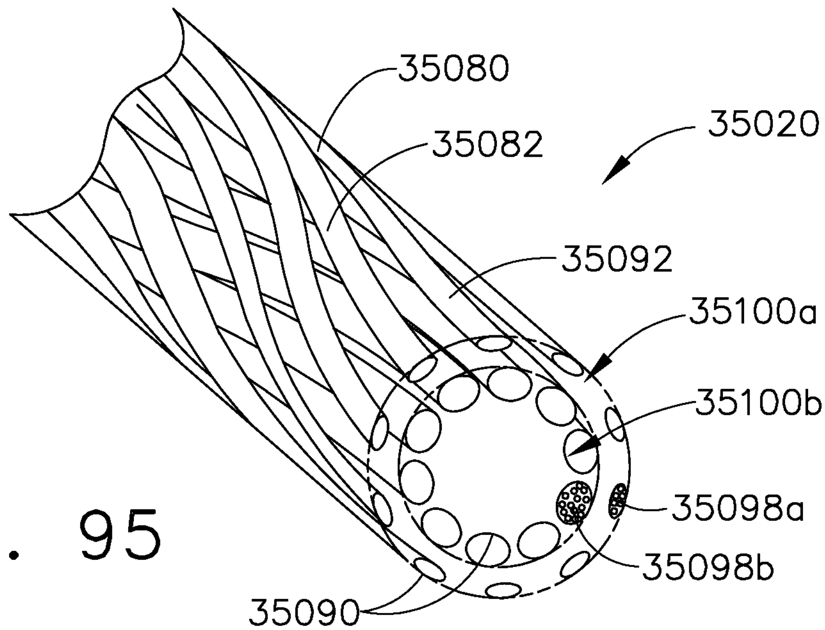

35080
35020
35082
35092
35100a
35100b
35098a
35098b
35090

FIG. 95

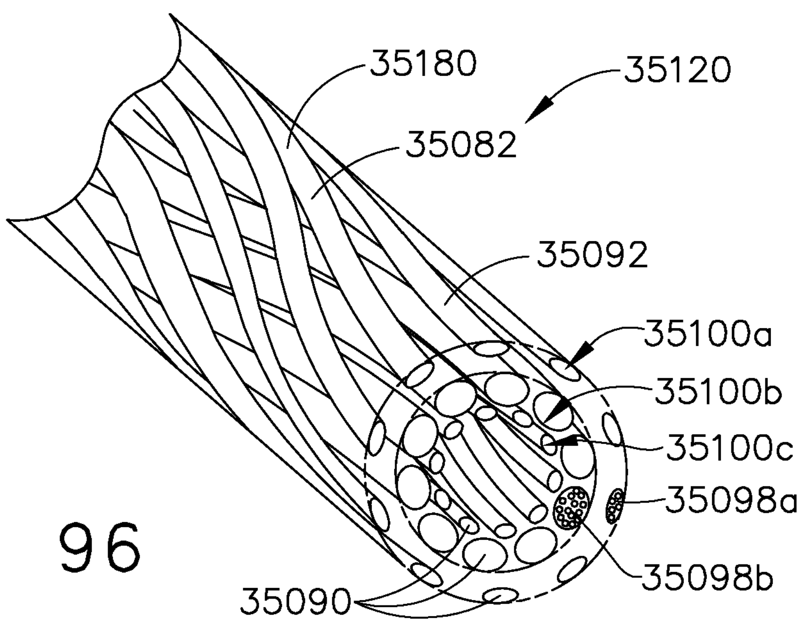

35180
35120
35082
35092
35100a
35100b
35100c
35098a
35098b
35090

FIG. 96

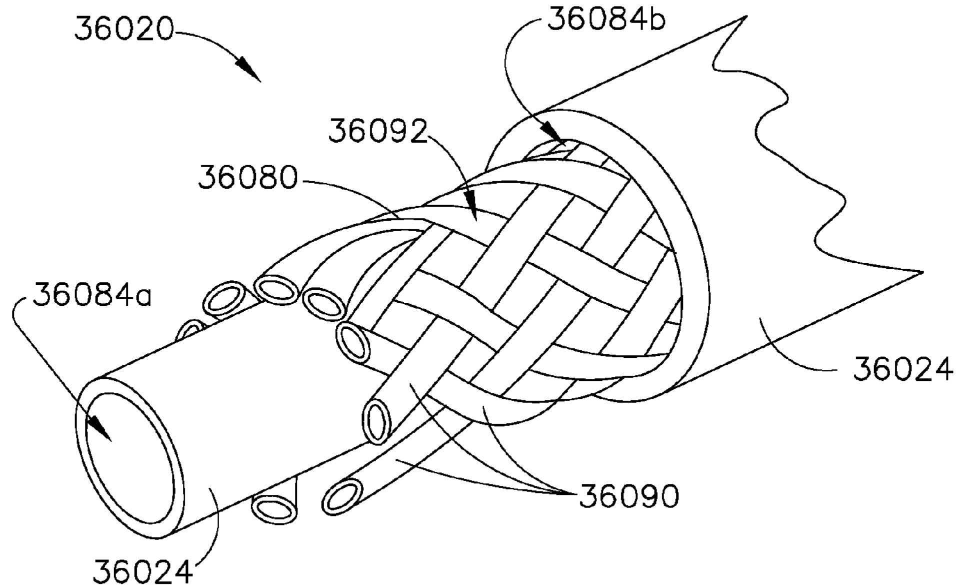

36020
36084b
36092
36080
36084a
36024
36090
36024

FIG. 97

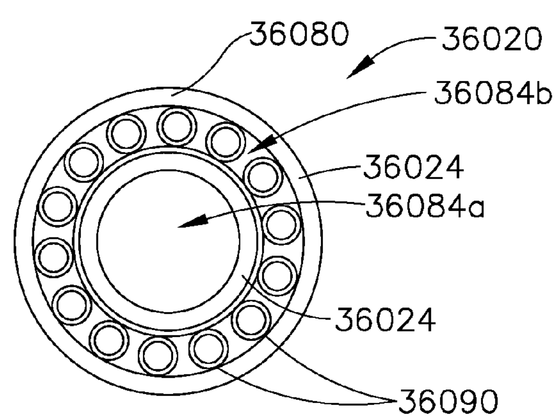

36080
36020
36084b
36024
36084a
36024
36090

FIG. 98

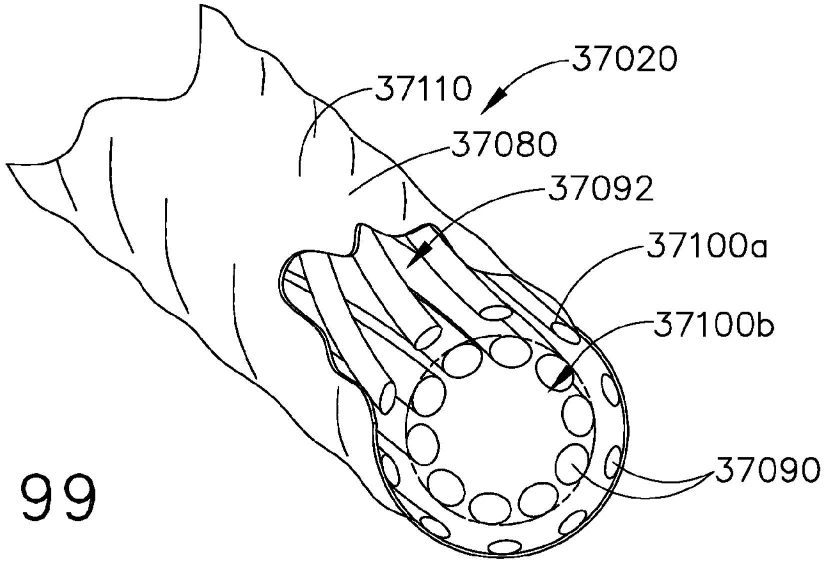


FIG. 99

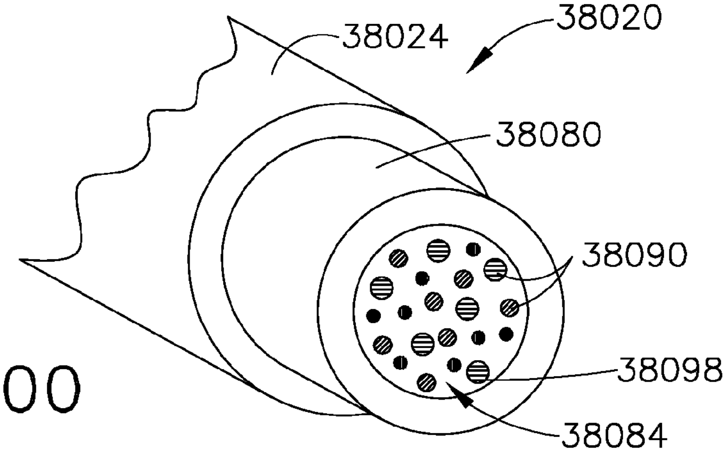


FIG. 100

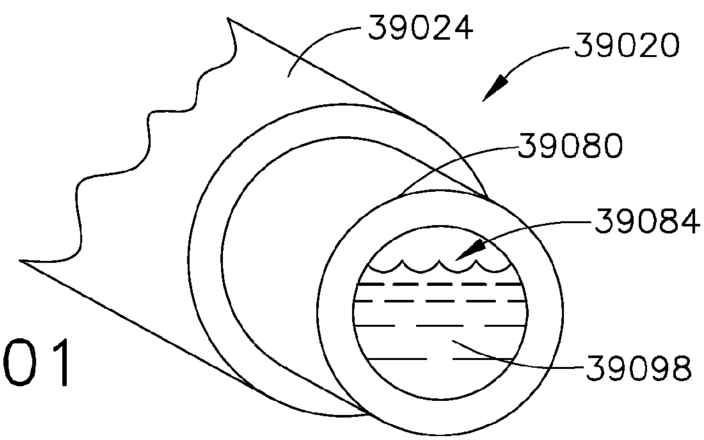


FIG. 101

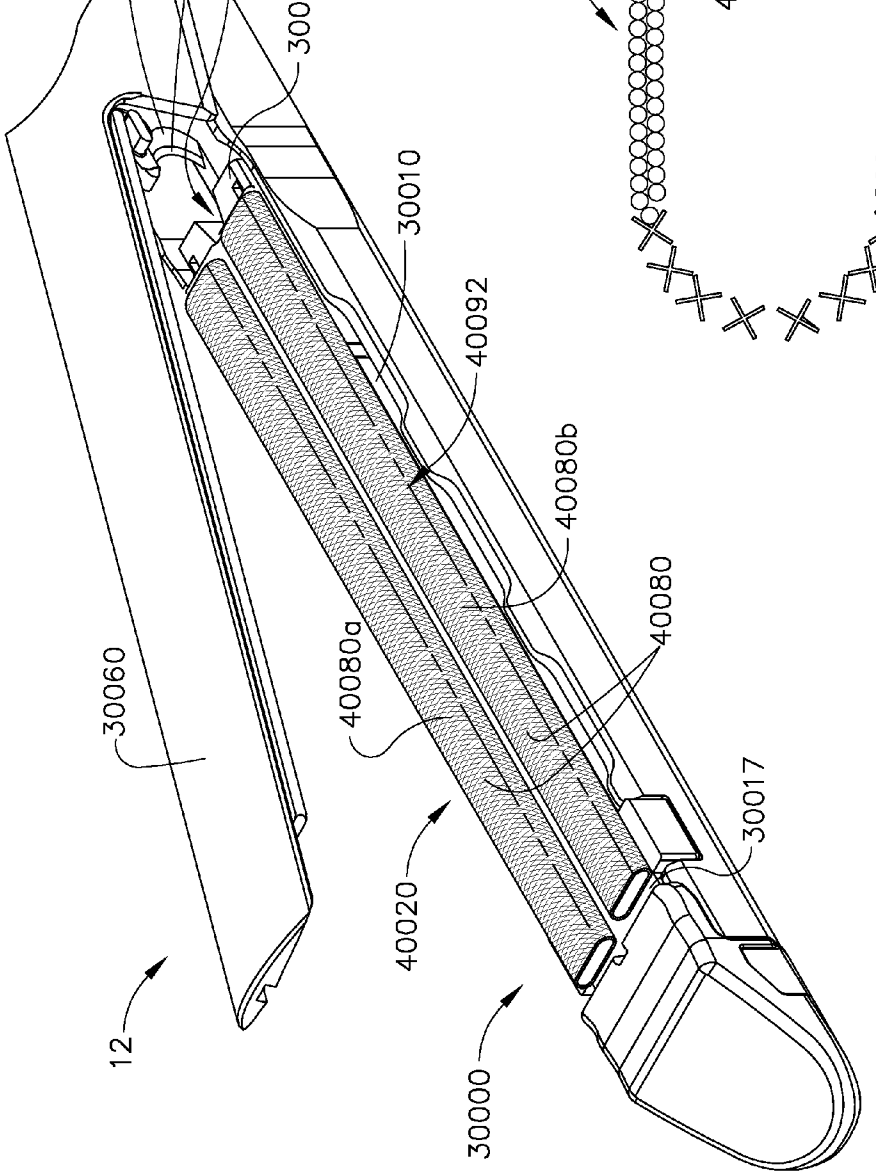


FIG. 102

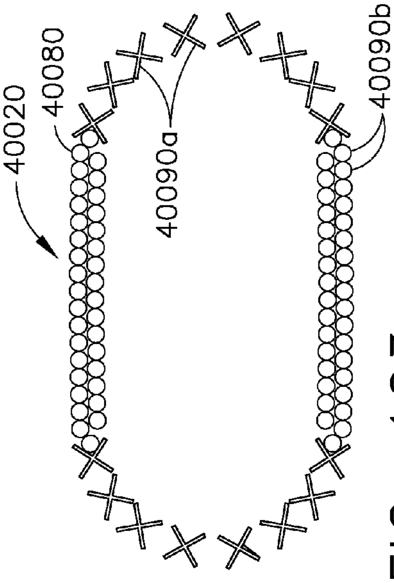


FIG. 103

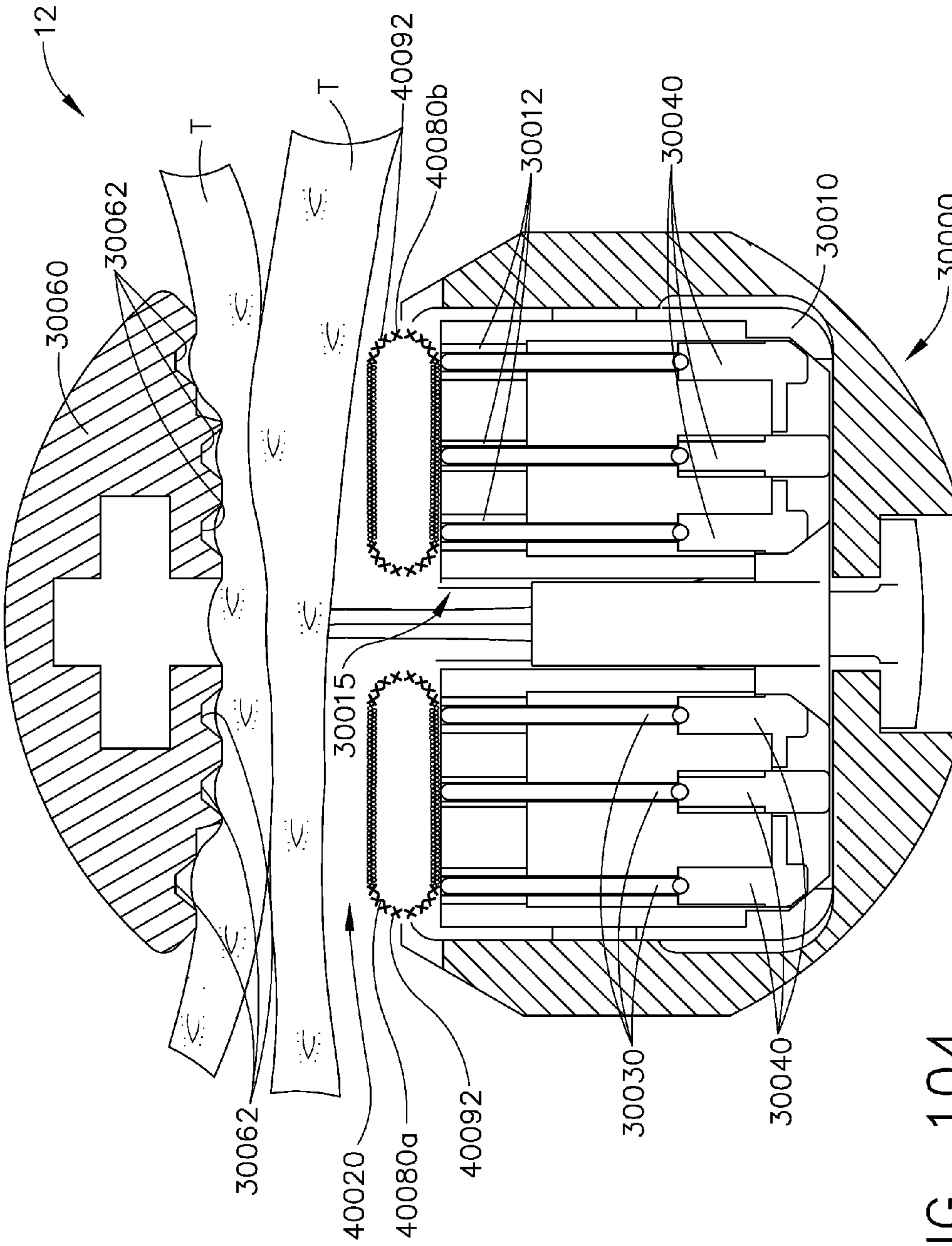

12
T
T
40092
40080b
30062
30060
30012
30040
30010
30000
30015
30062
40020
40080a
40092
30030
30040

FIG. 104

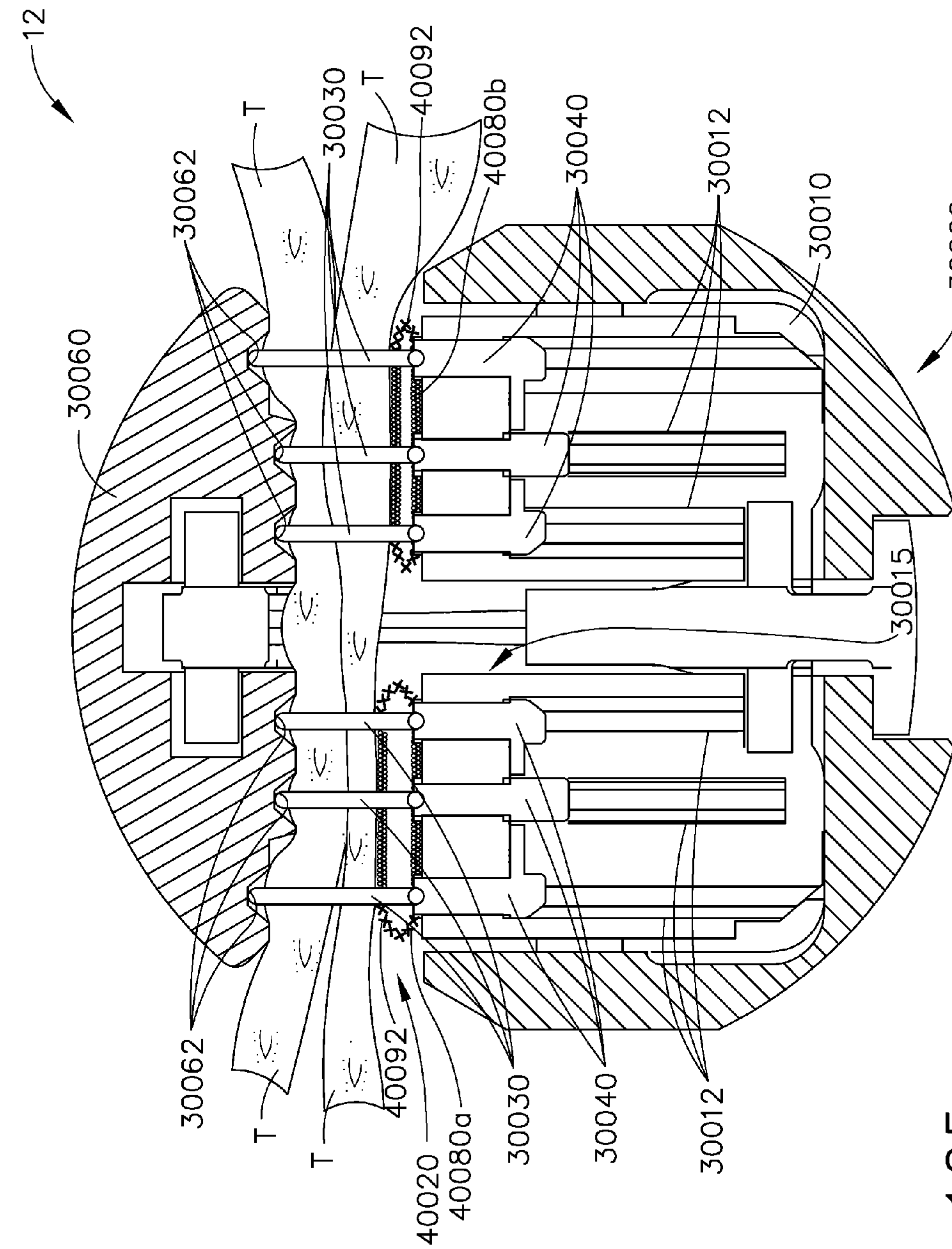

12
T
30030
T
40092
40080b
30062
30040
30012
30010
30000
30060
30015
30062
T
T
40092
40020
40080a
30030
30040
30012

FIG. 105

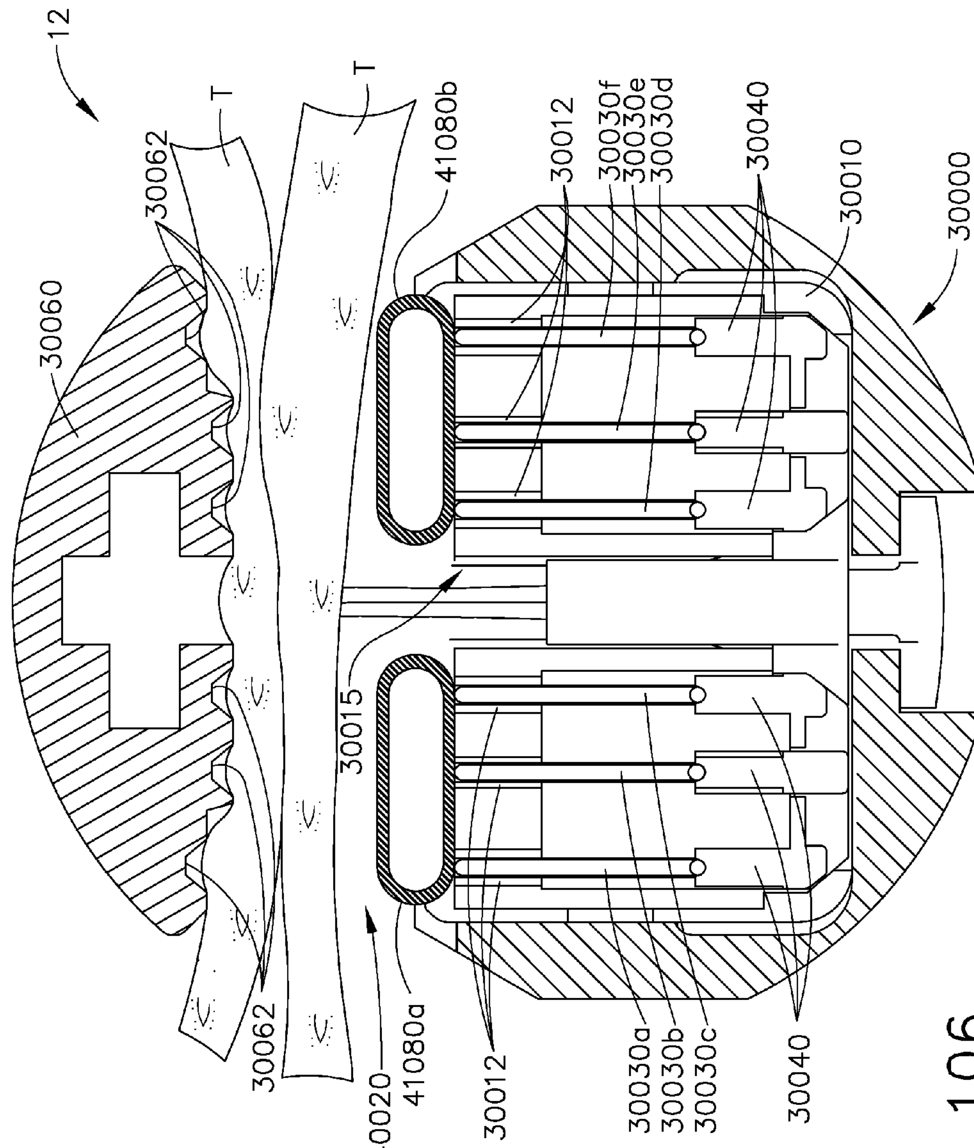

12
T
T
41080b
30062
30012
30030f
30030e
30030d
30040
30010
30000
30060
30015
30062
40020
41080a
30012
30030a
30030b
30030c
30040

FIG. 106

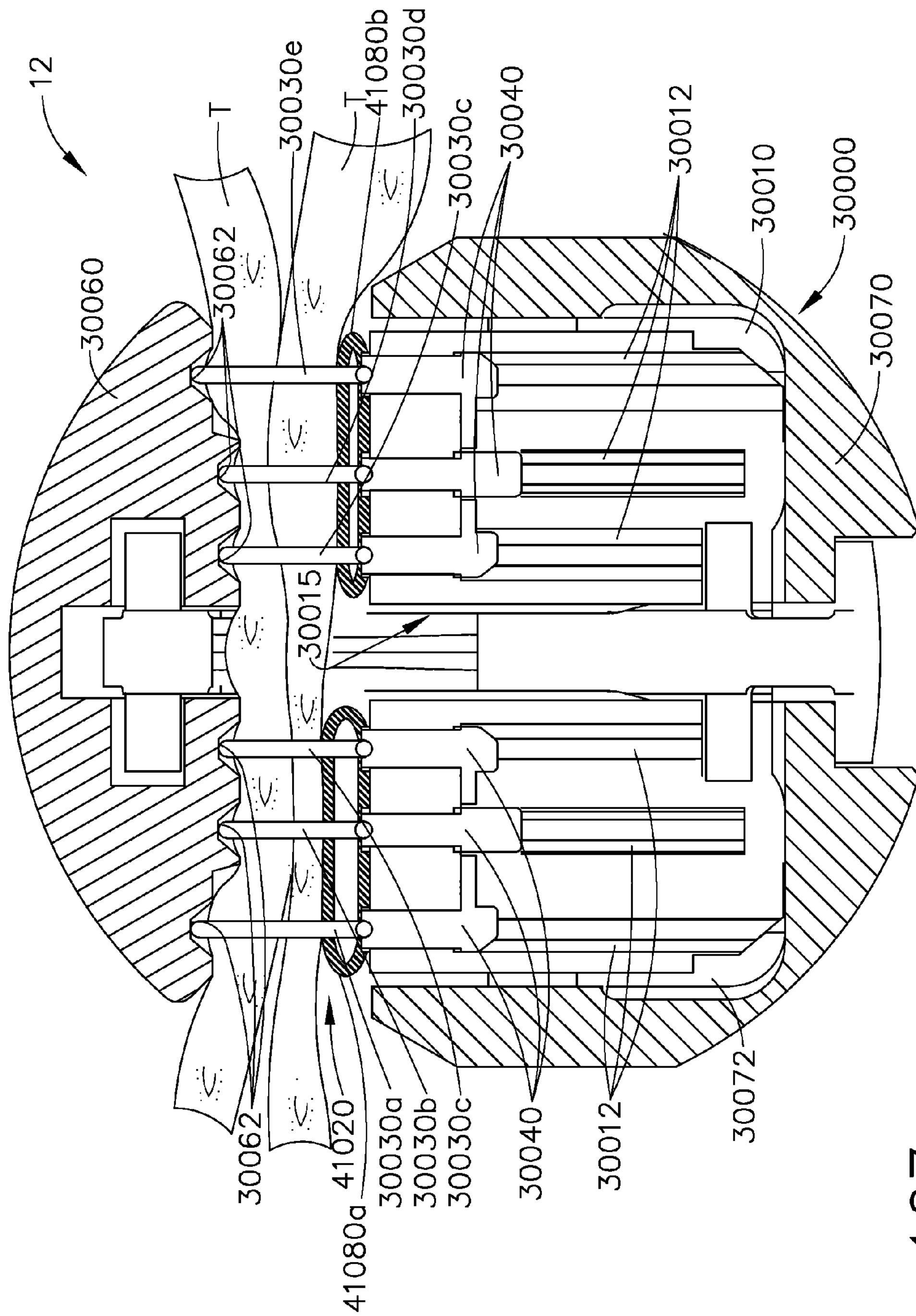

12
T
30030e
T
41080b
30030d
30030c
30040
30012
30010
30000
30070
30060
30062
30015
30062
41020
41080a
30030a
30030b
30030c
30040
30012
30072

FIG. 107

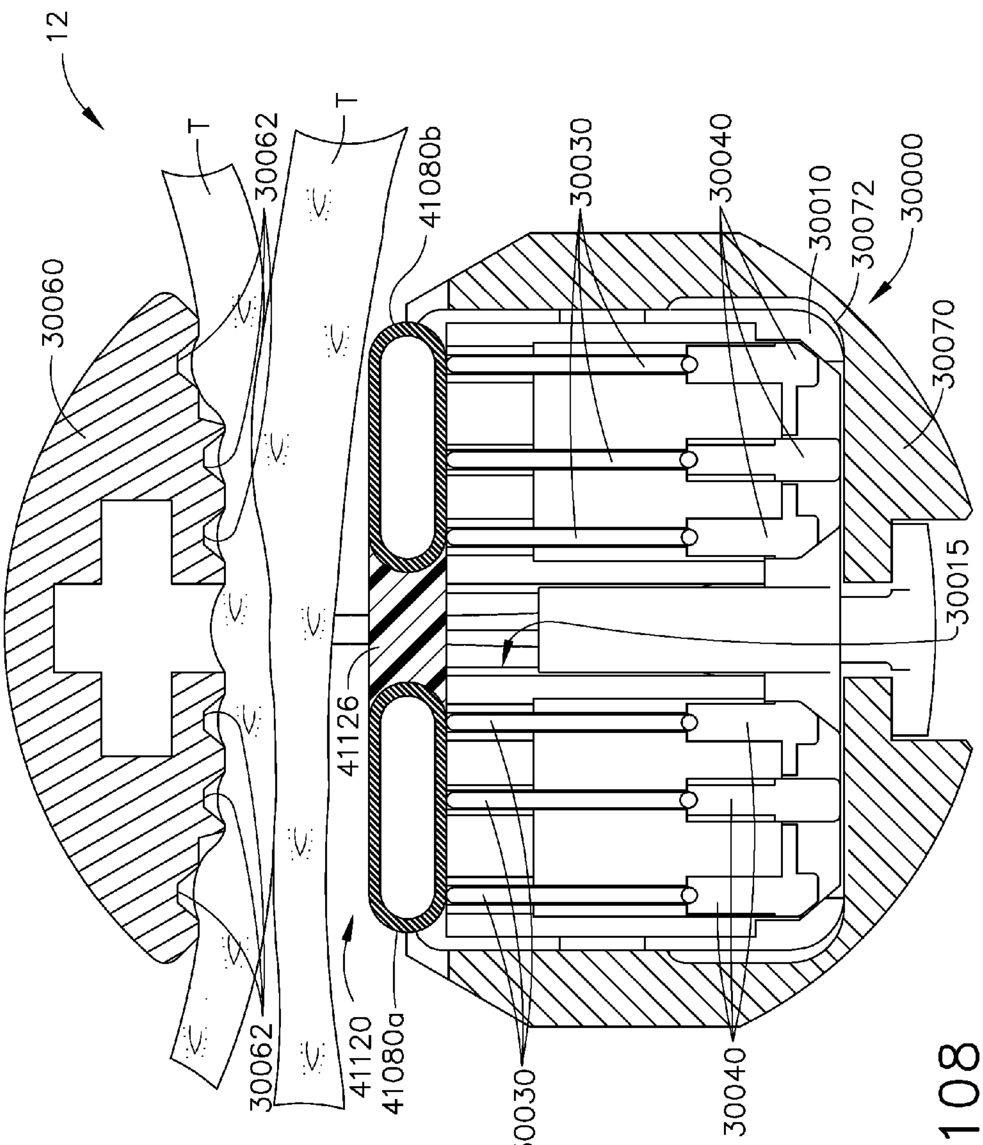

12
T
30062
T
41080b
30030
30040
30010
30072
30000
30060
30070
30015
41126
30062
41120
41080a
30030
30040

FIG. 108

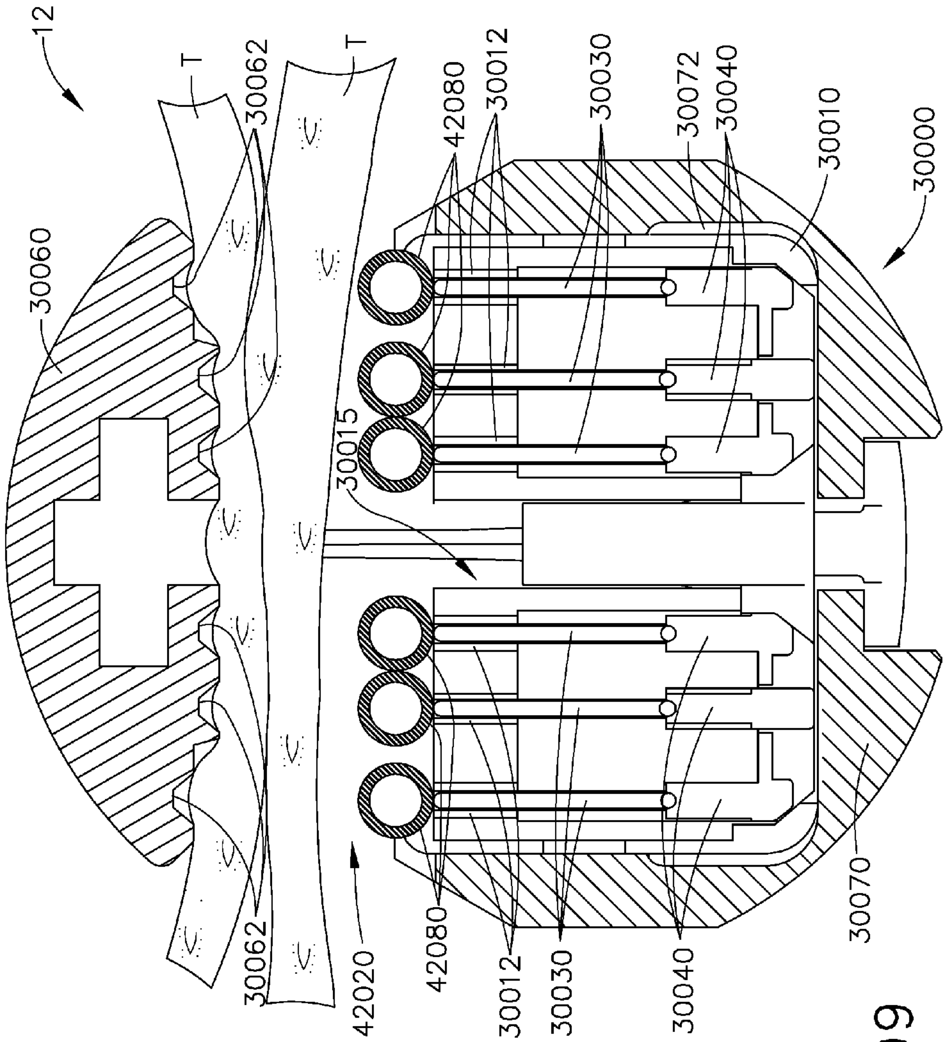

12
T
T
30062
30060
42080
30012
30030
30072
30040
30010
30000
30015
30062
42020
42080
30012
30030
30040
30070

FIG. 109

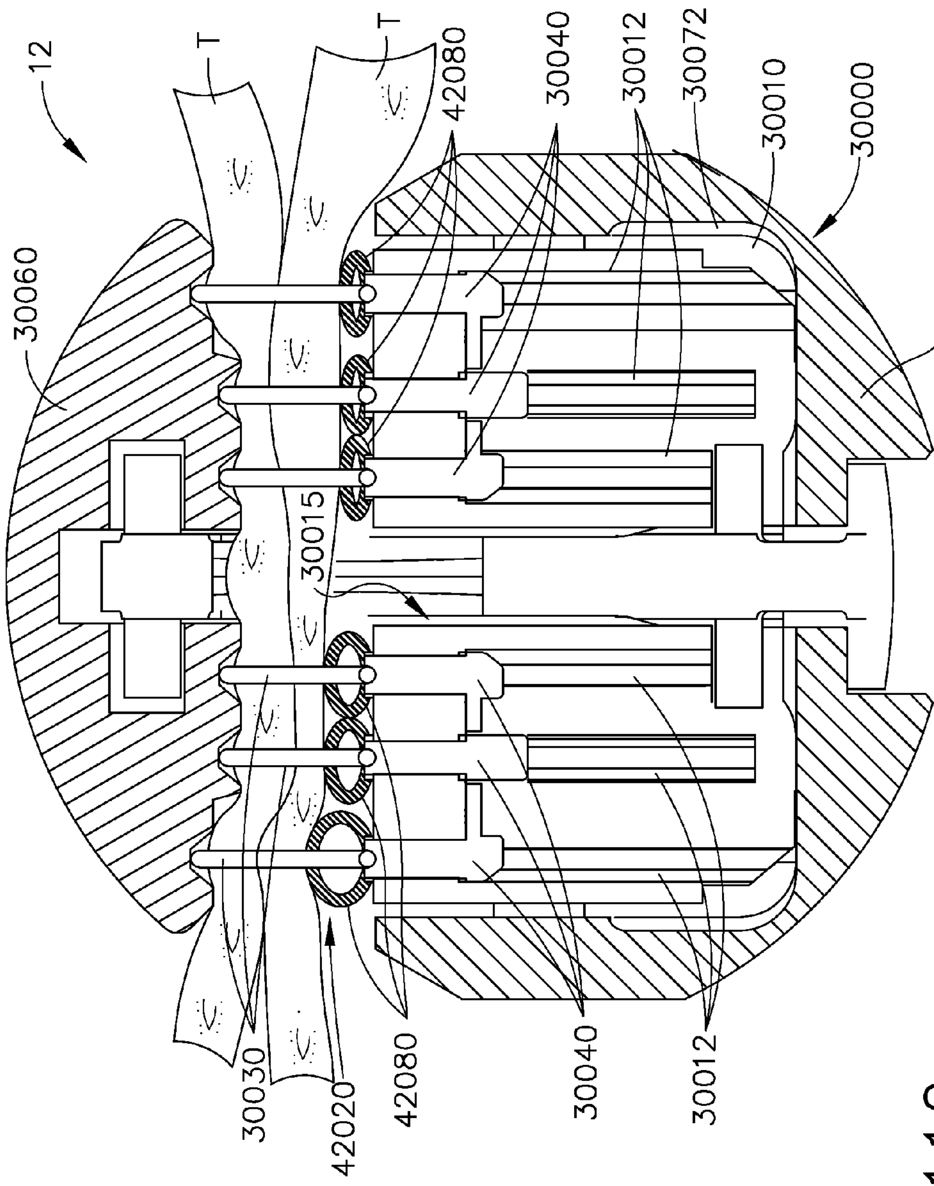

12
T
T
42080
30040
30012
30072
30010
30000
30070
30060
30015
30030
42020
42080
30040
30012

FIG. 110

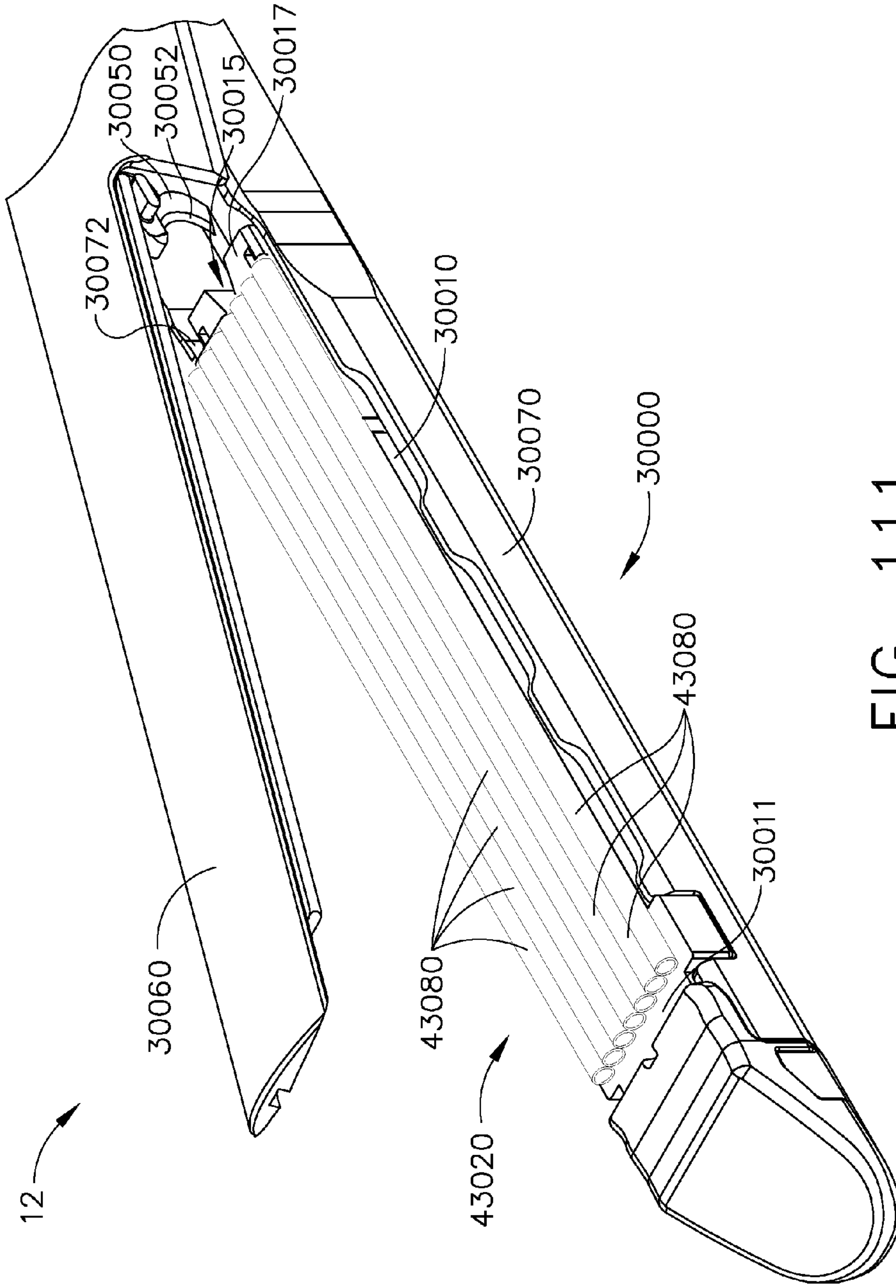

30050
30052
30015
30017
30072
30010
30070
30000
43080
30011
30060
43080
43020
12

FIG. 111

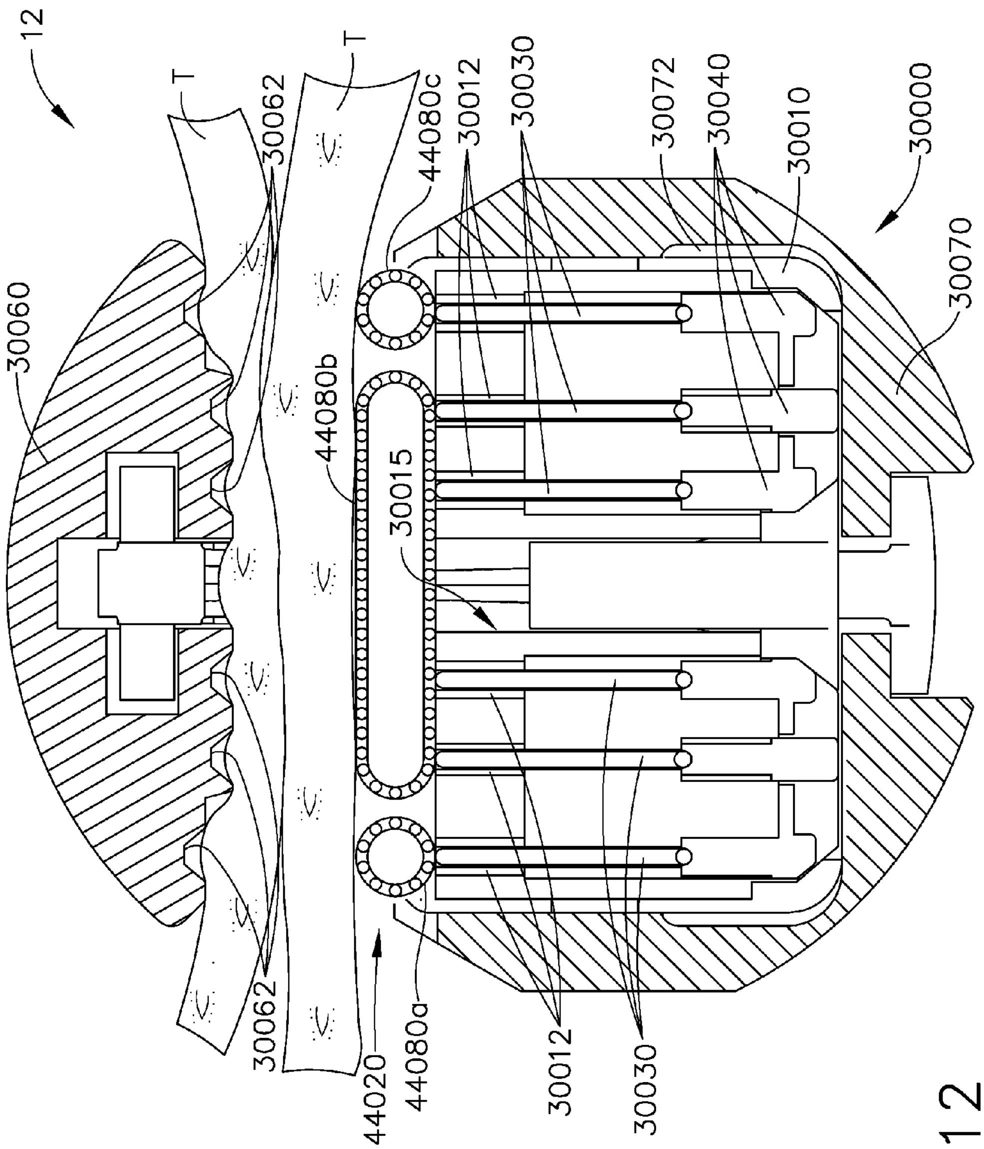

12
T
T
30062
44080c
30012
30030
30072
30040
30010
30000
30070
30060
44080b
30015
30062
44020
44080a
30012
30030

FIG. 112

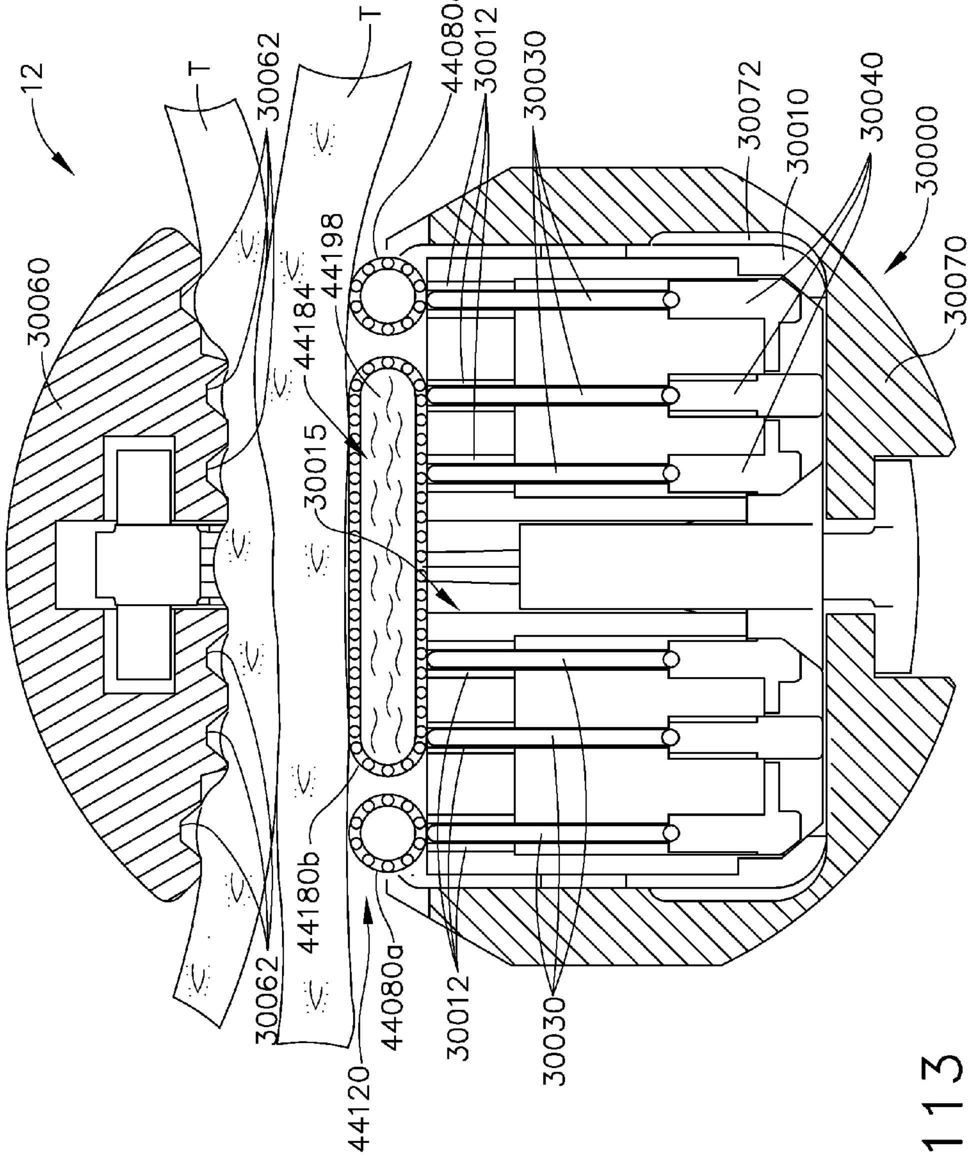
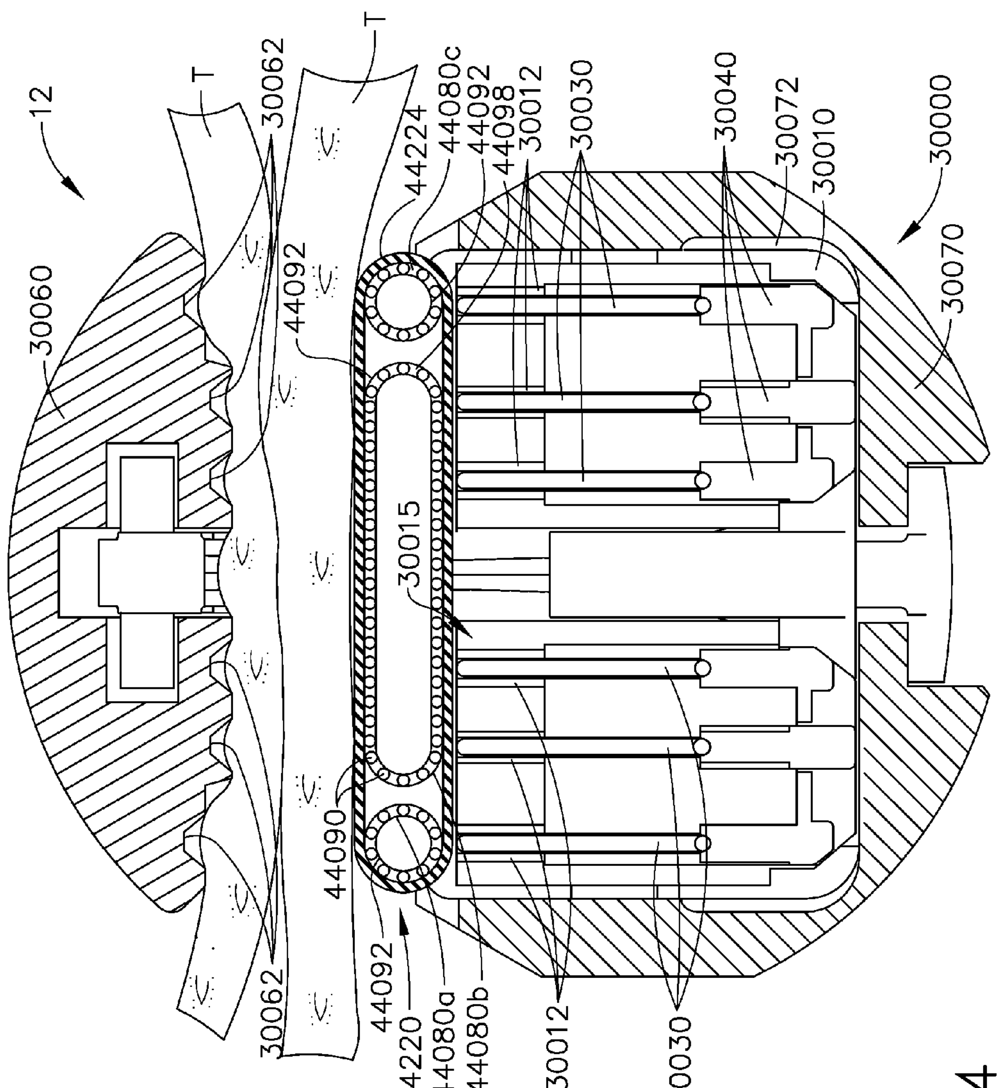

12
T
T
30062
44080c
30012
30030
30072
30010
30040
30000
30070
30060
44198
44184
30015
44180b
30062
44120
44080a
30012
30030

FIG. 113



12
30060
T
30062
T
44224
44080c
44092
44098
30012
30030
30040
30072
30010
30000
30070
44092
30015
44090
30062
44092
44220
44080a
44080b
30012
30030

FIG. 114

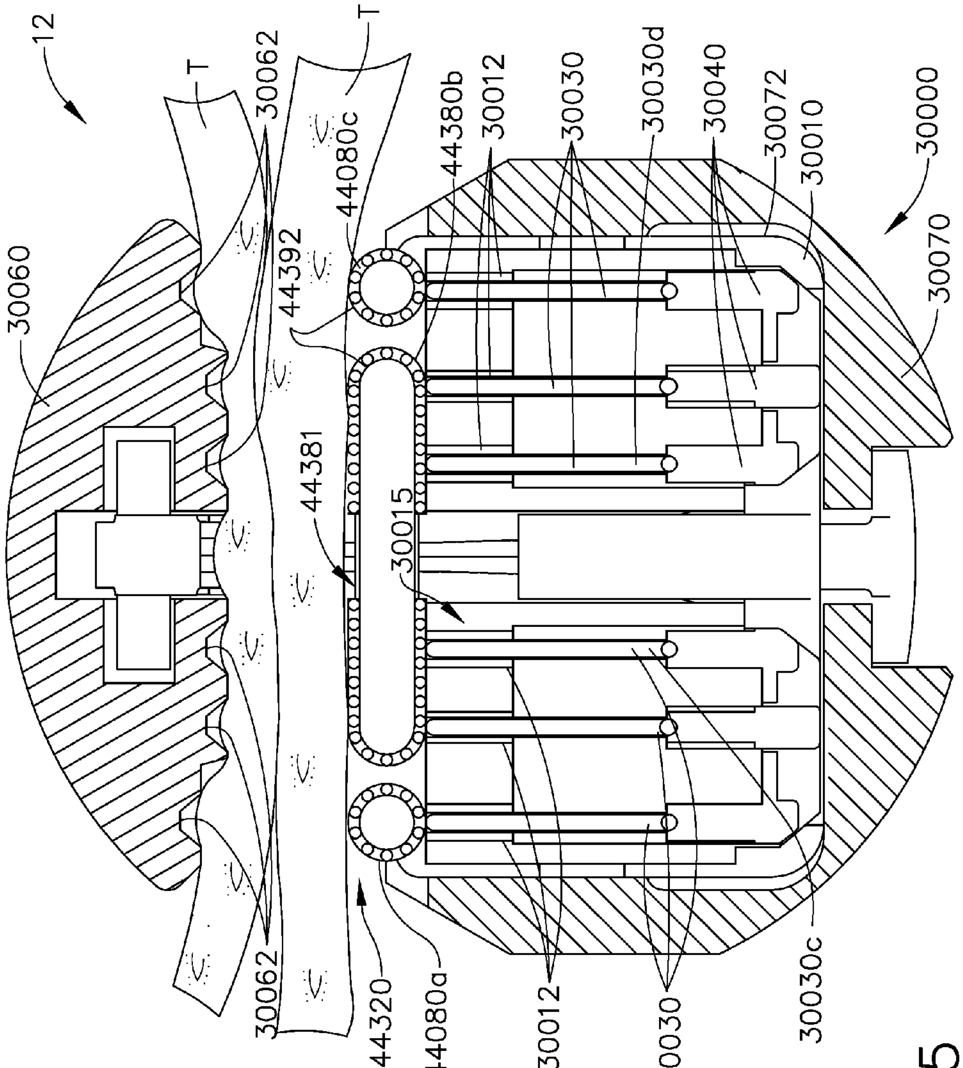

12
T
30062
T
44080c
44380b
30012
30030
30030d
30040
30072
30010
30000
30070
30060
44392
44381
30015
30062
44320
44080a
30012
30030
30030c

FIG. 115

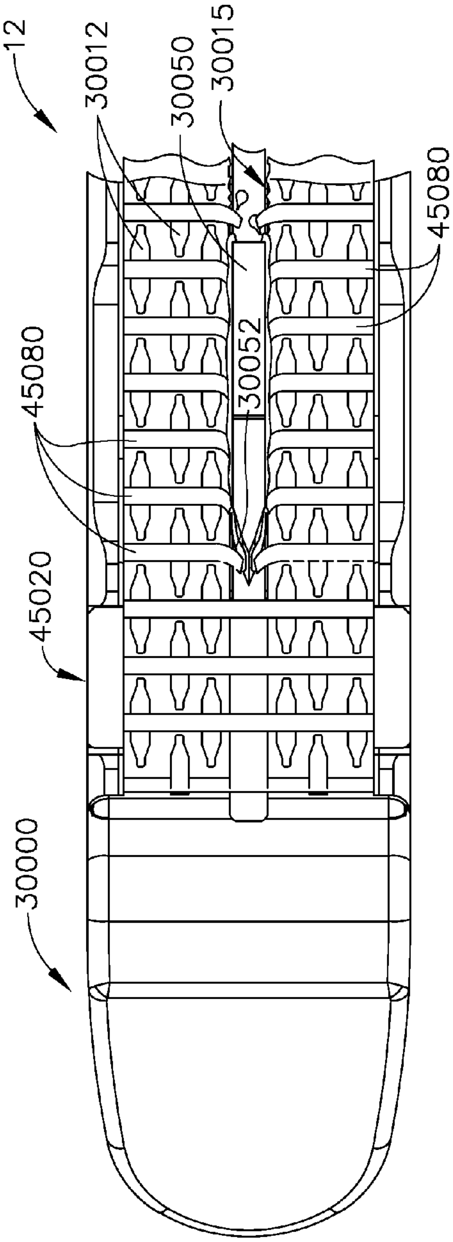


FIG. 116

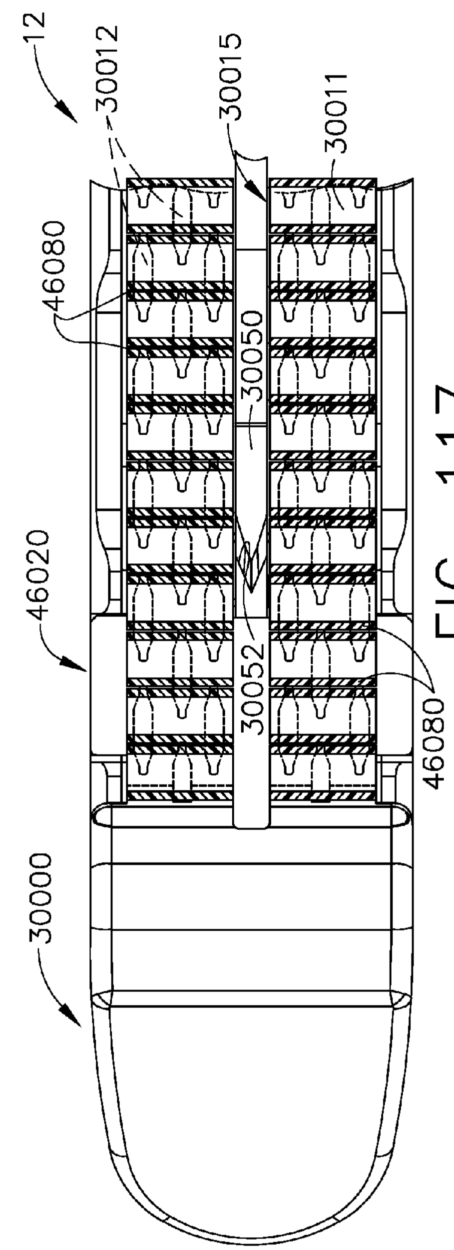


FIG. 117

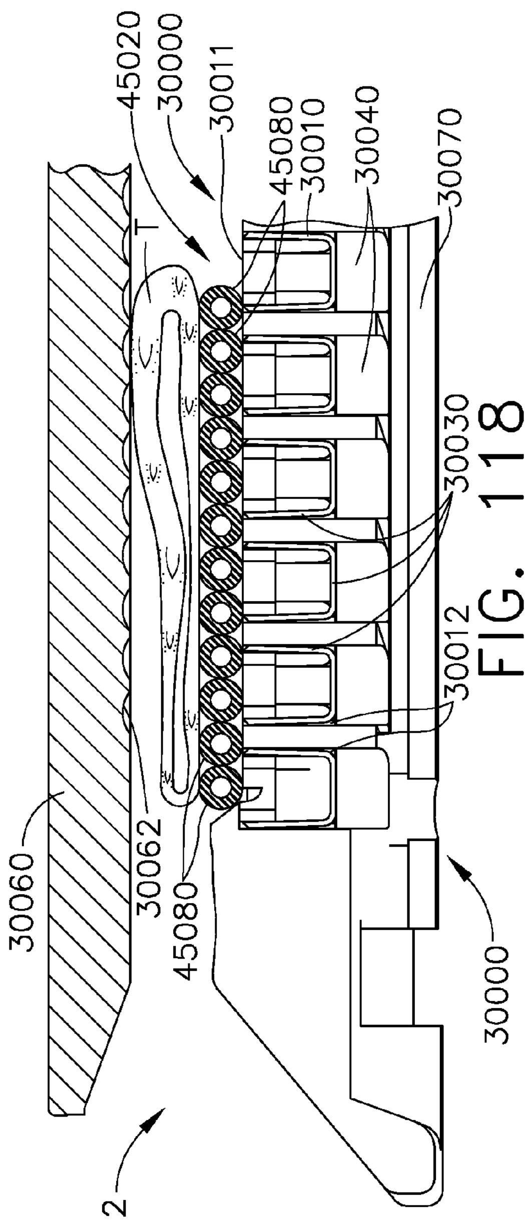


FIG. 118

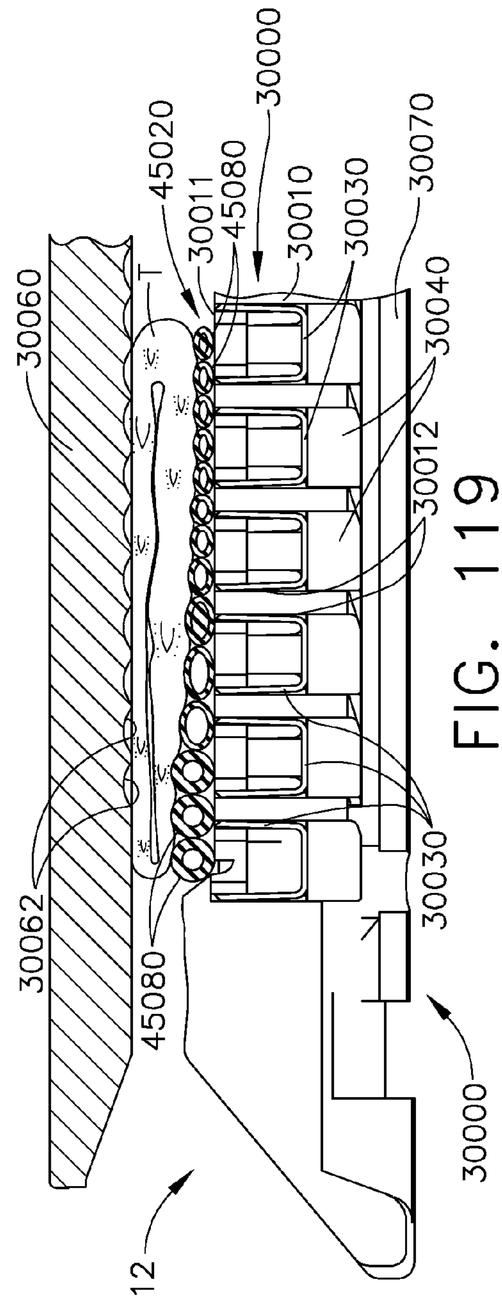


FIG. 119

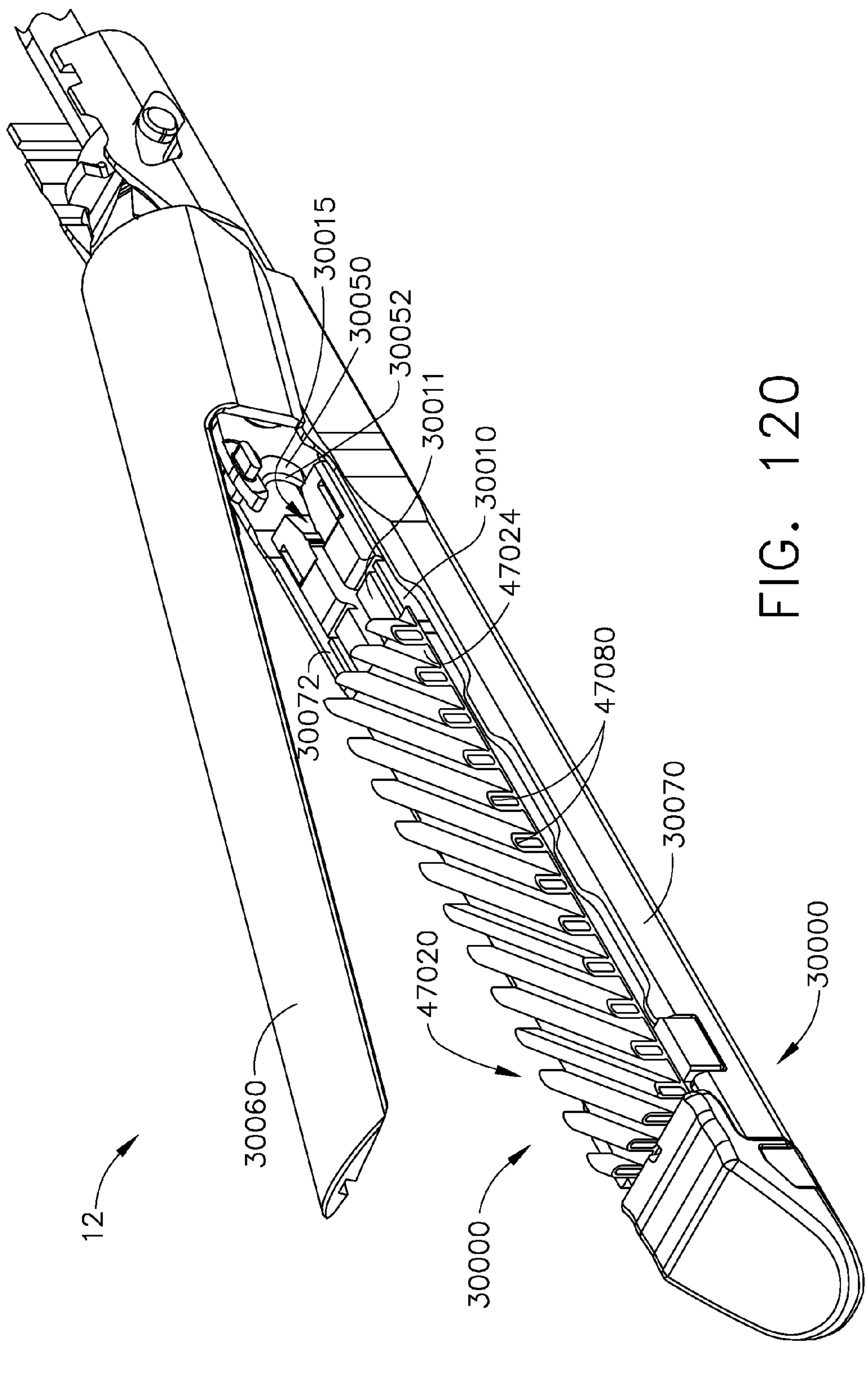

30015
30050
30052
30011
30010
47024
30072
47080
30070
30000
47020
30060
12
30000

FIG. 120

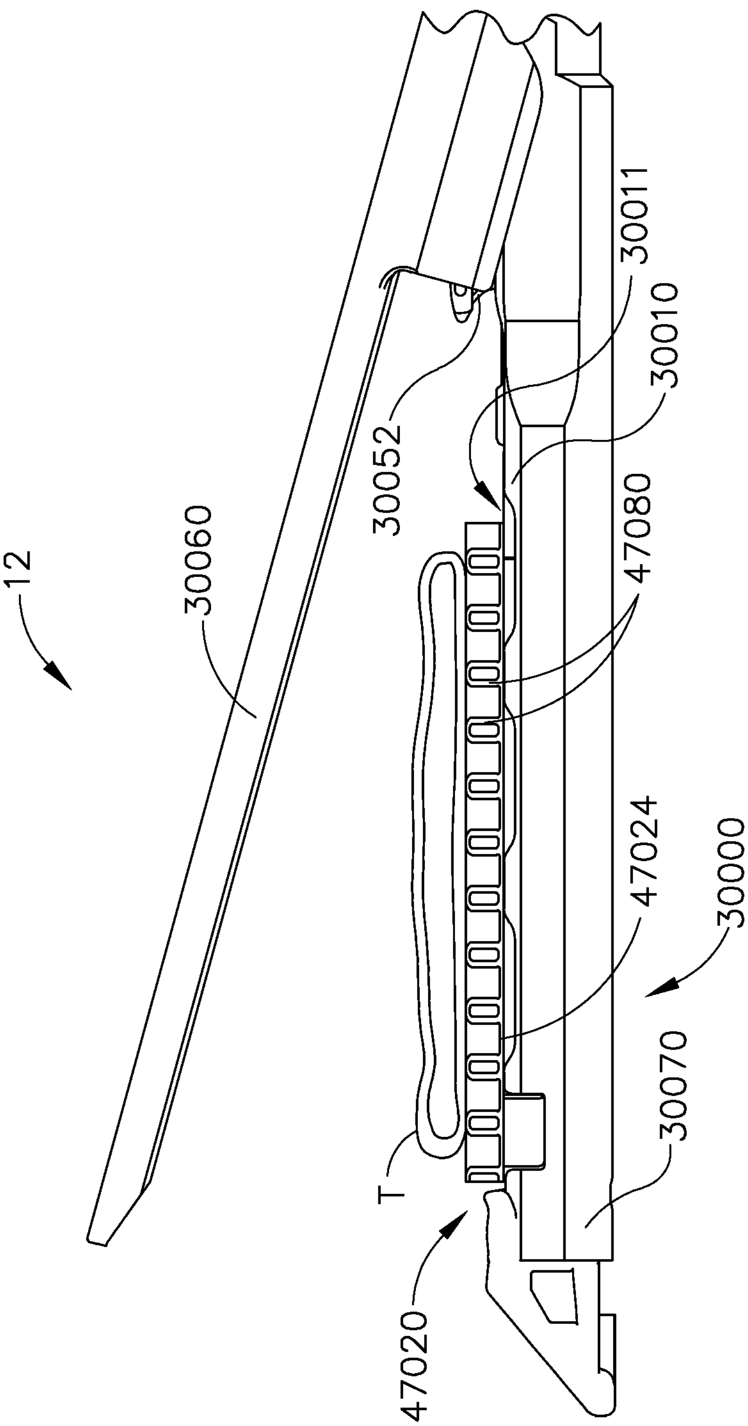


FIG. 121

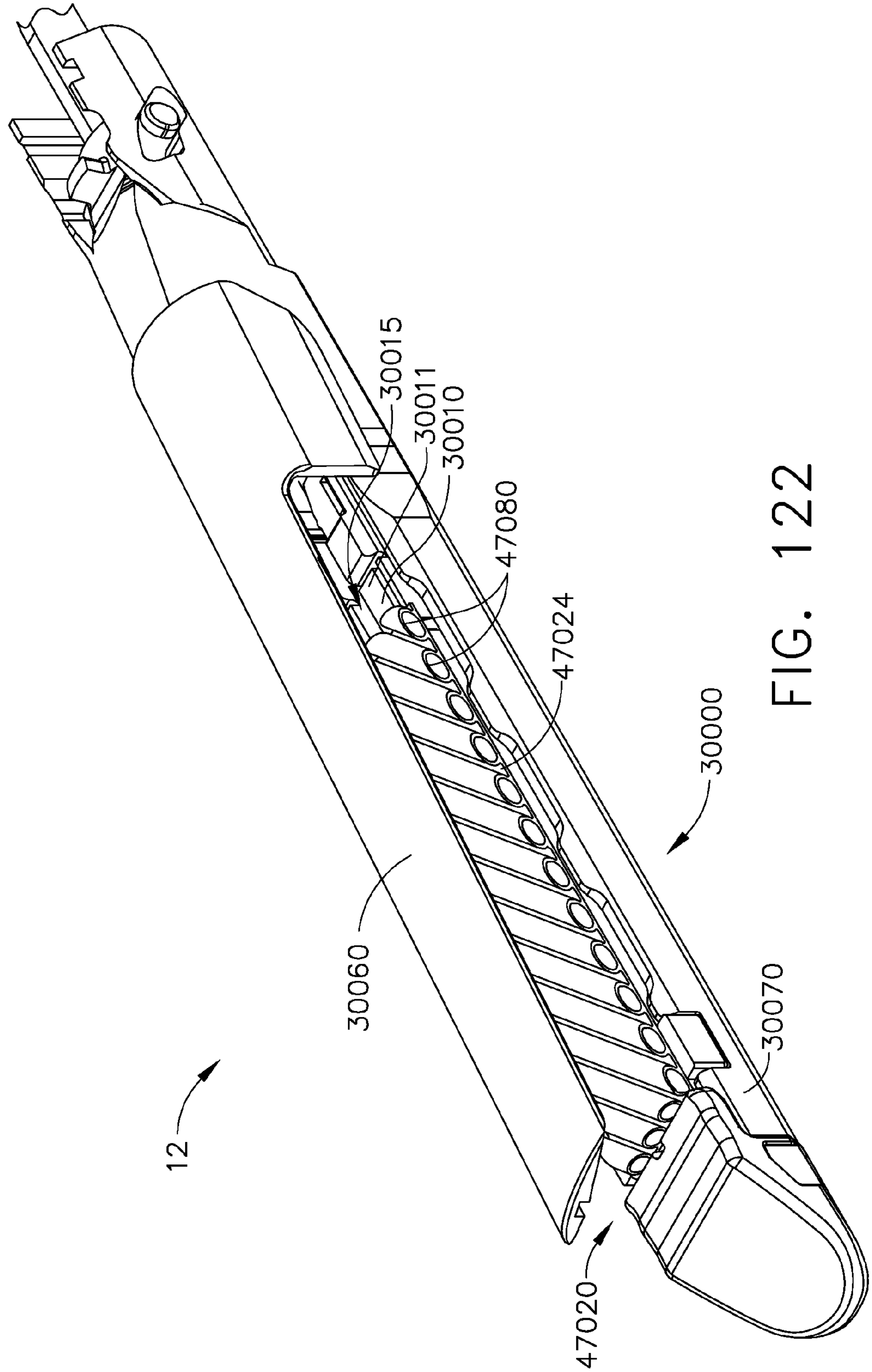


FIG. 122

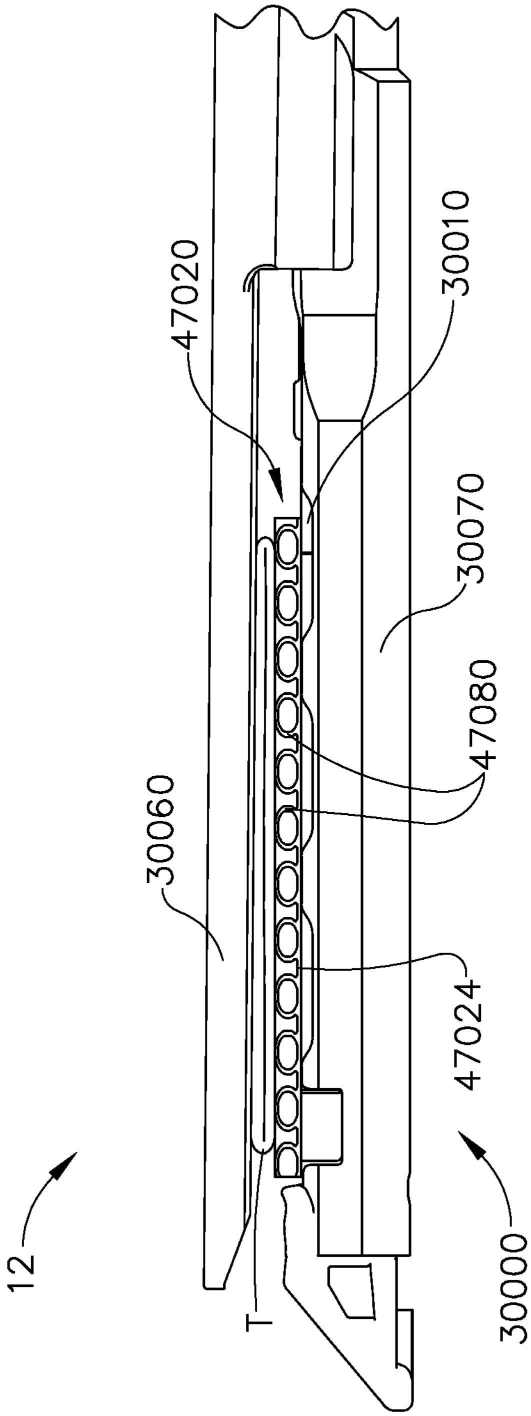


FIG. 123

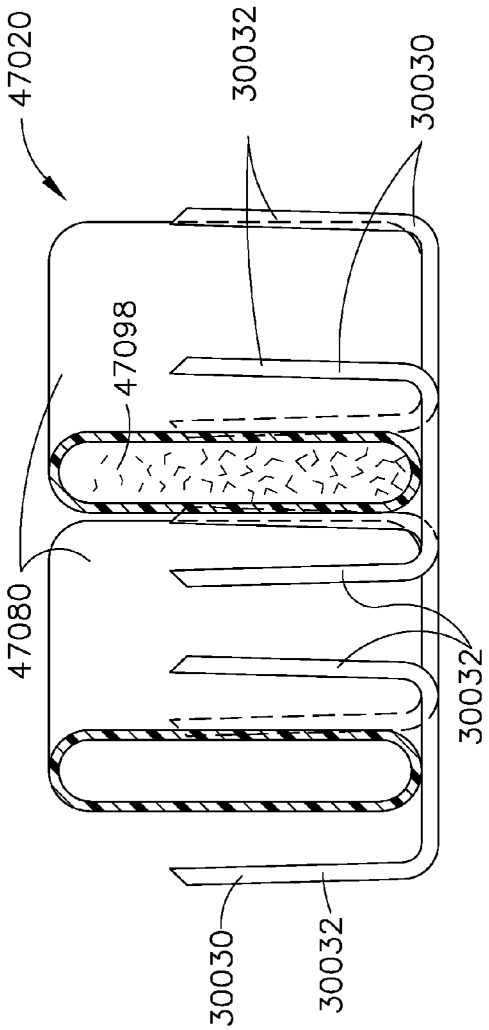


FIG. 124

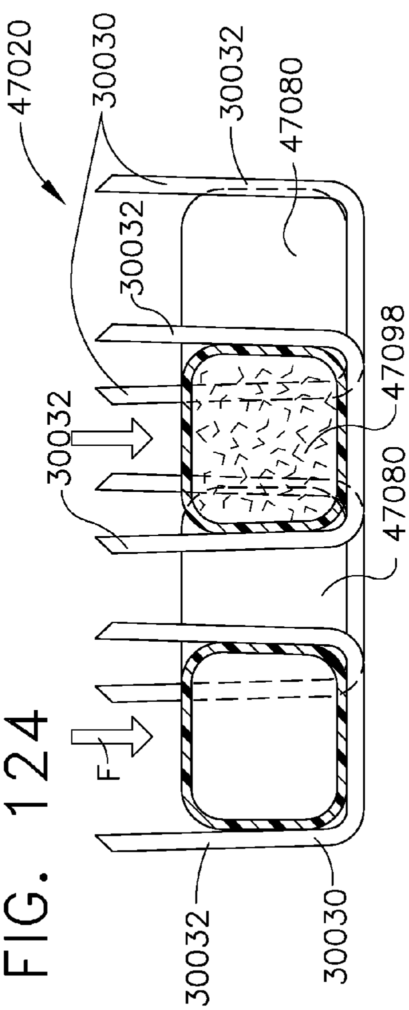


FIG. 125

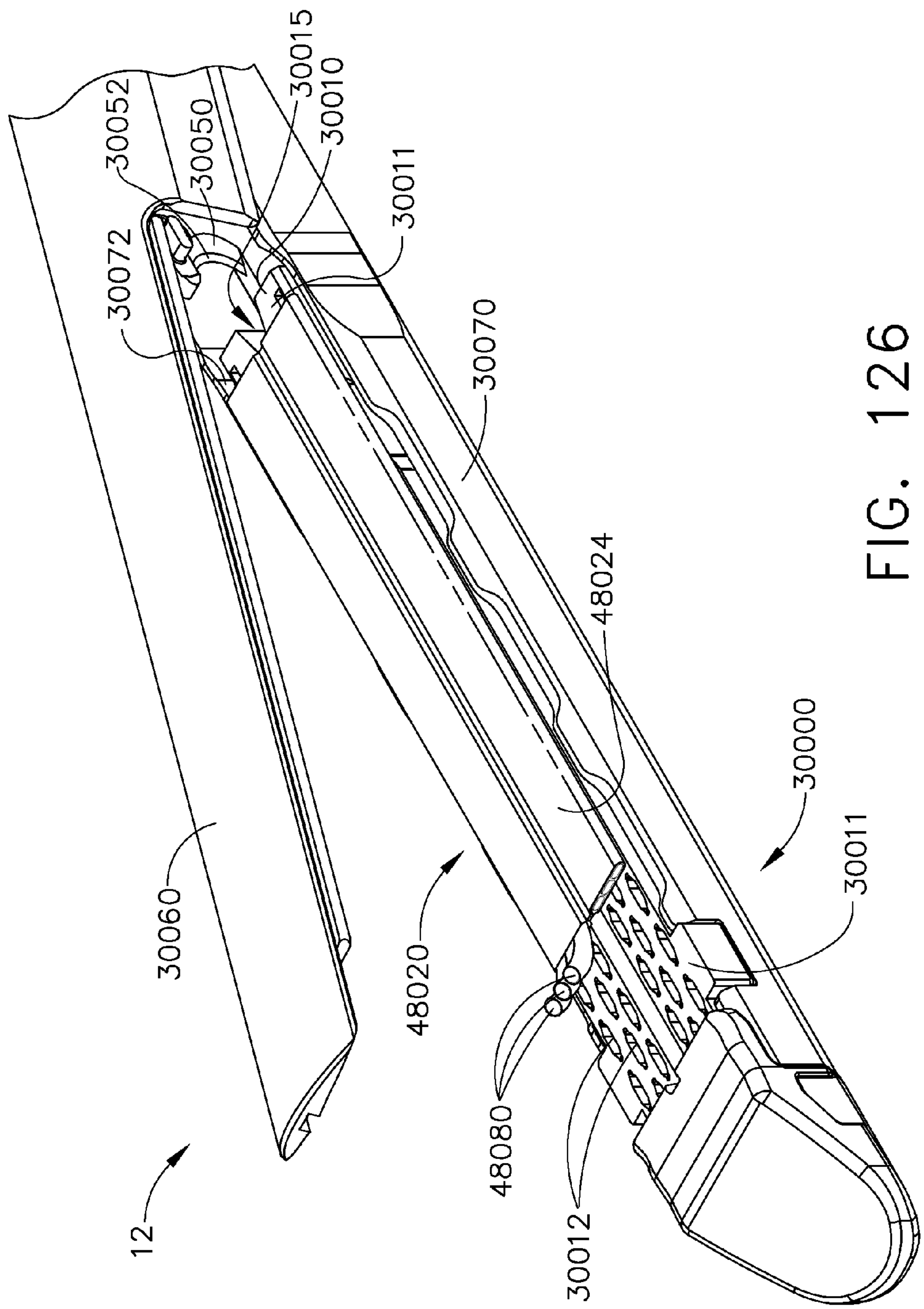
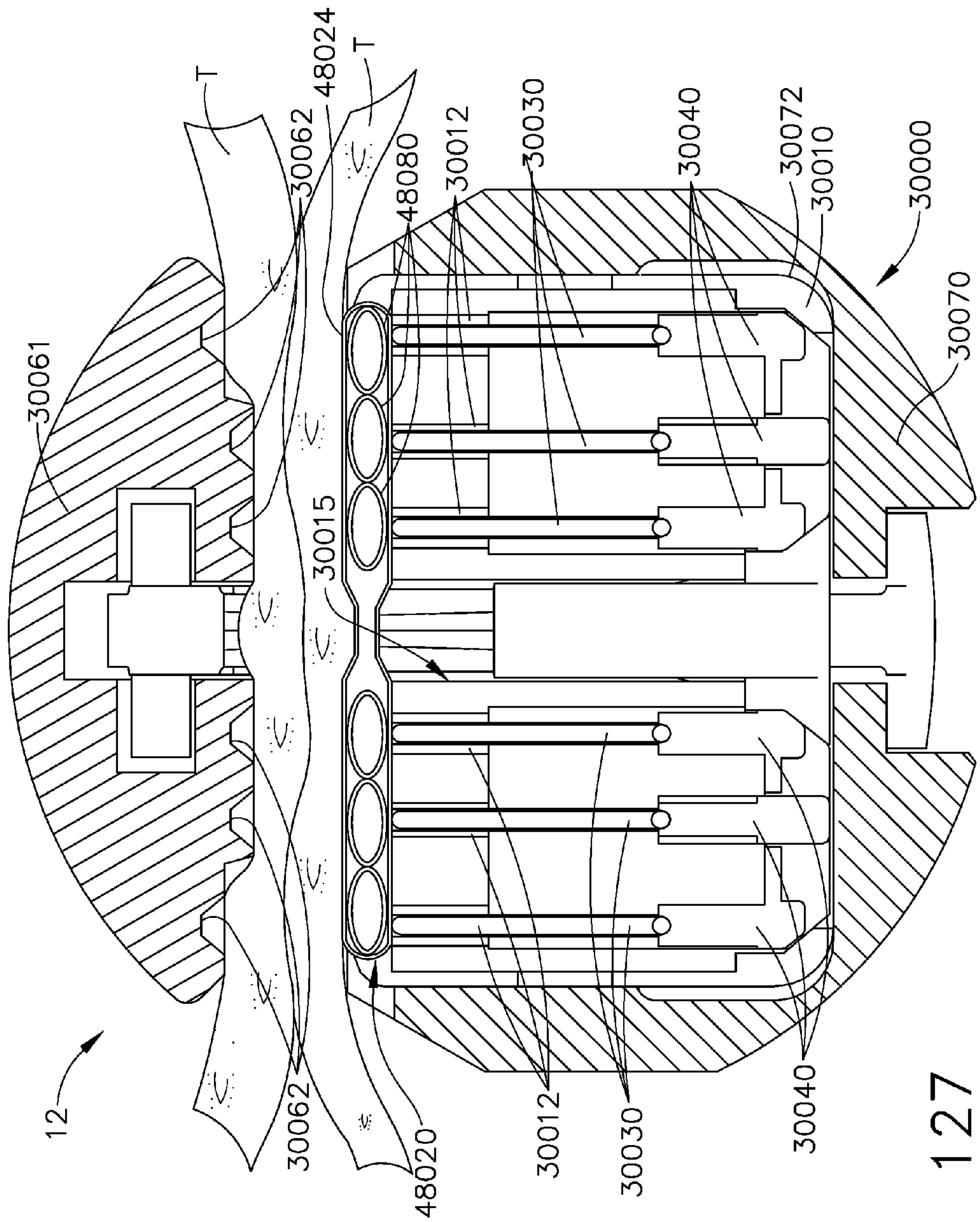

30015
30010
30052
30050
30011
30072
30070
48024
30000
30011
30060
48020
48080
30012
12

FIG. 126



T
48024
T
30062
48080
30012
30030
30040
30072
30010
30000
30070
30061
30015
12
30062
48020
30012
30030
30040

FIG. 127

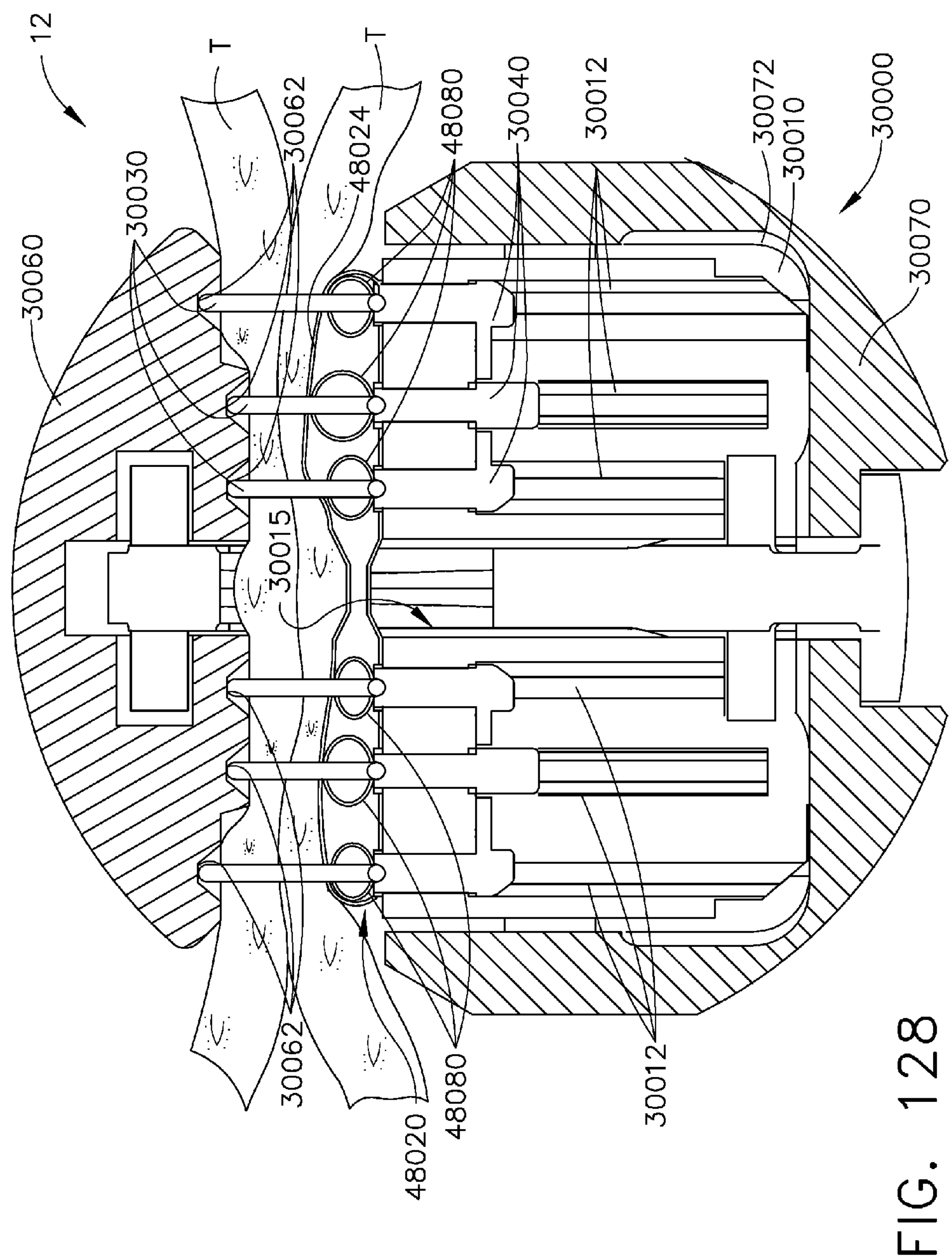

12
T
T
30060
30030
30062
48024
48080
30040
30012
30072
30010
30000
30070
30015
30062
48080
30012
48020
48080

FIG. 128

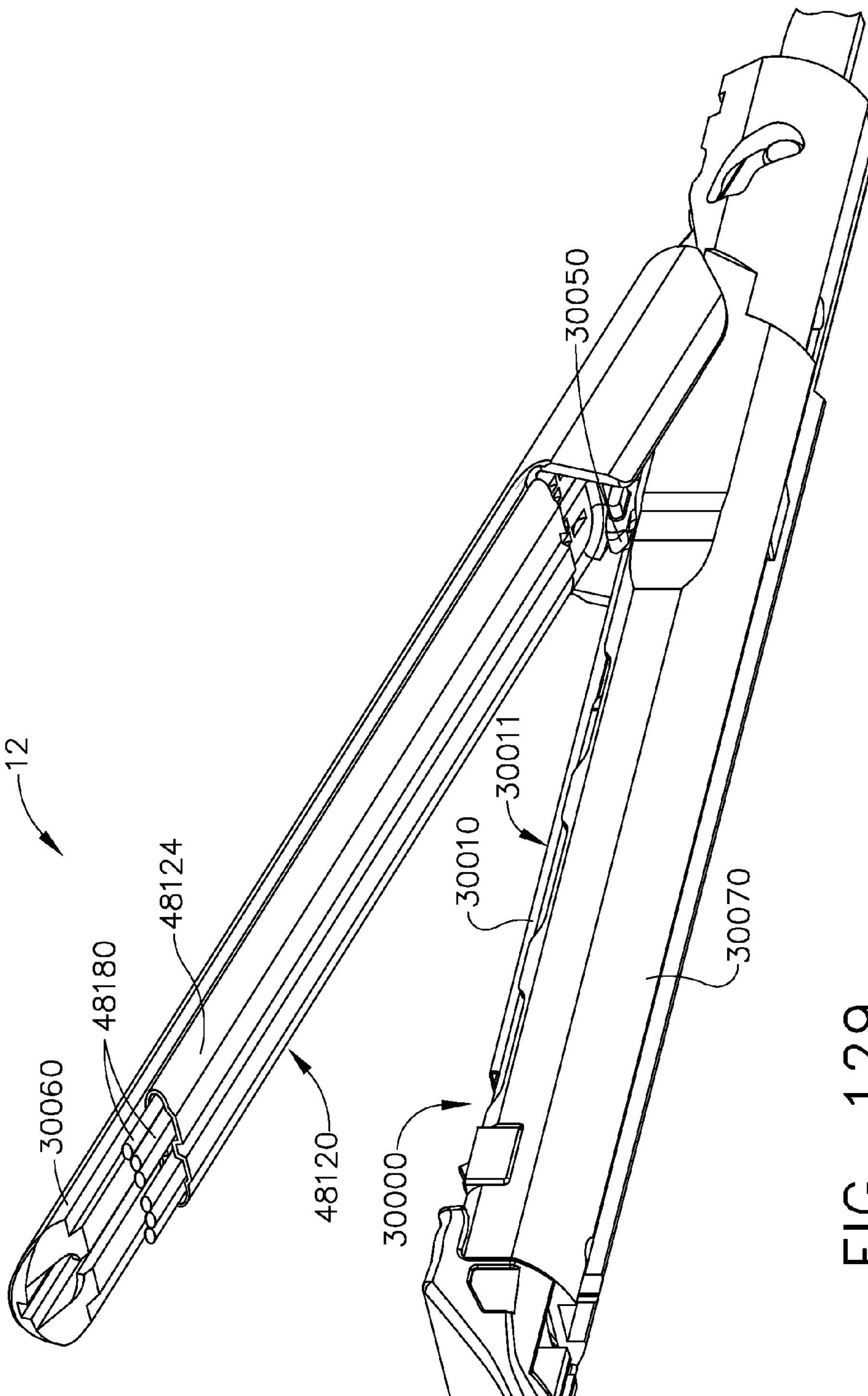


FIG. 129

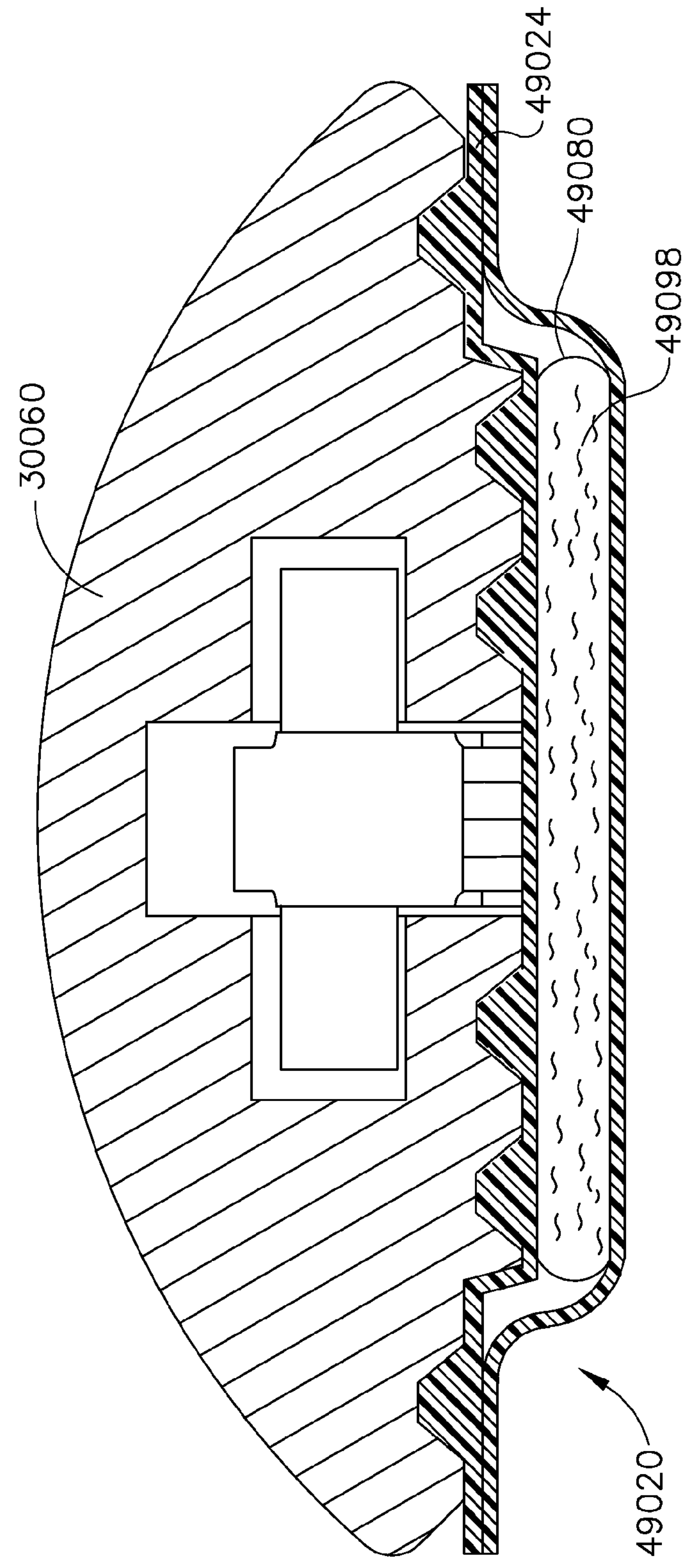


FIG. 130

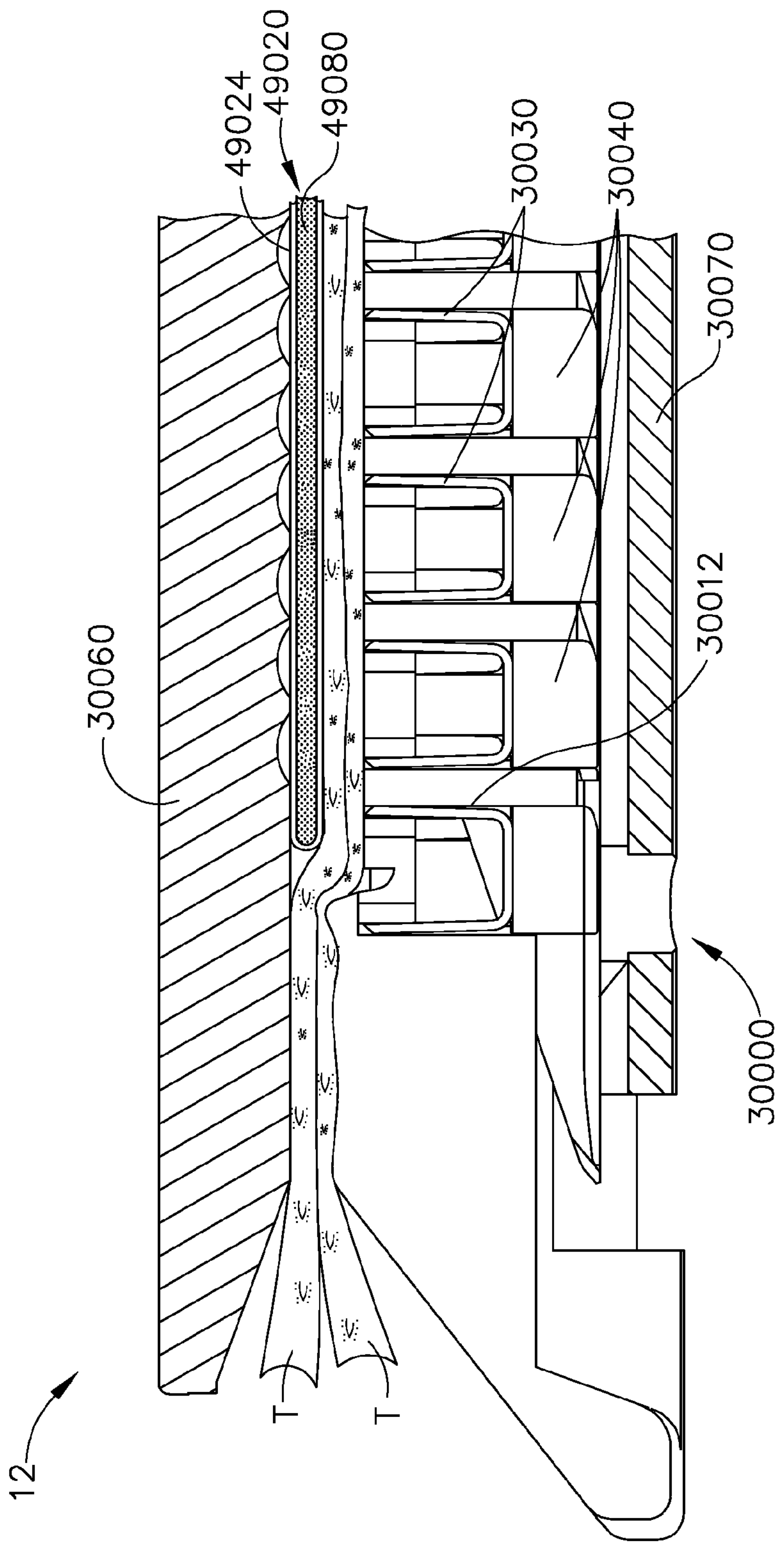
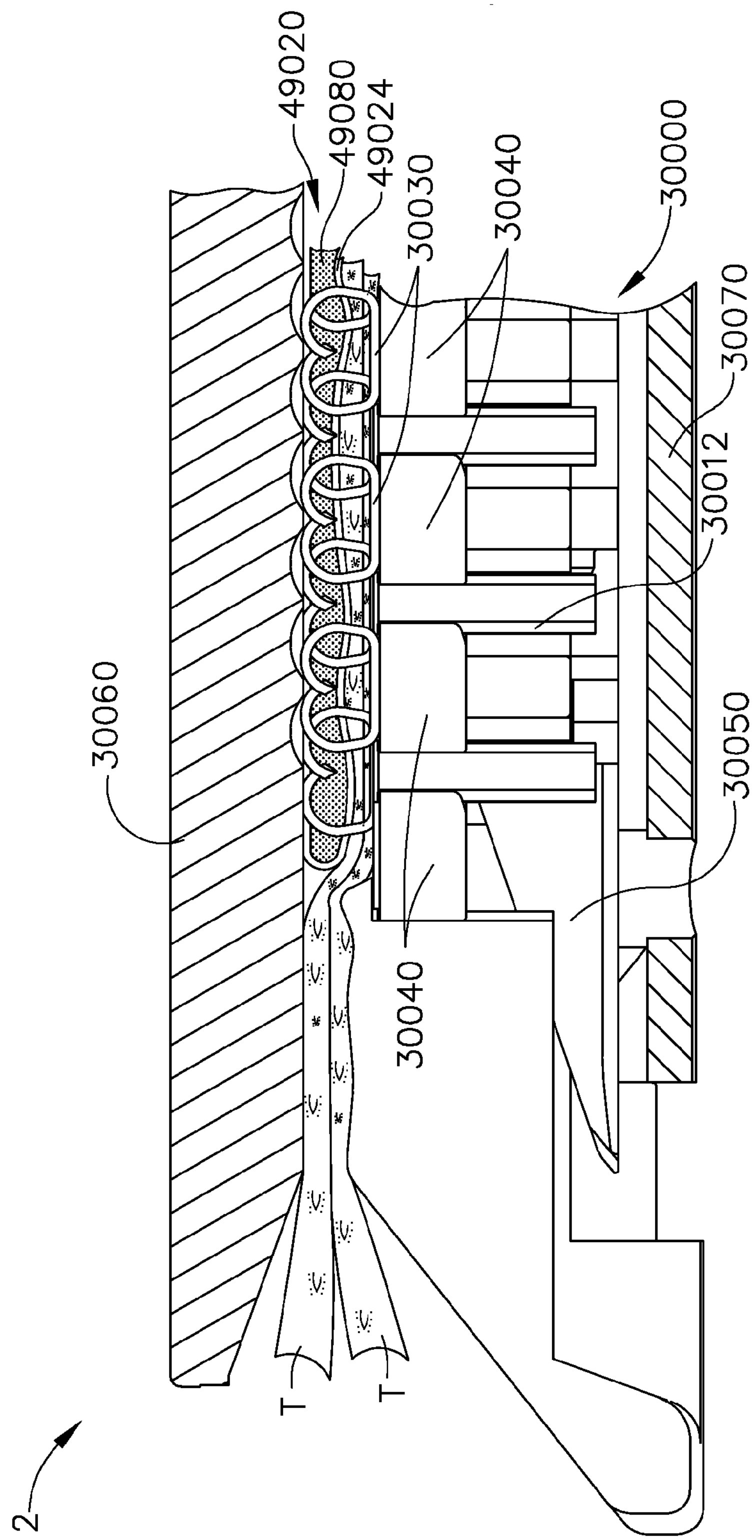


FIG. 131



49020
49080
49024
30030
30040
30000
30070
30012
30060
30050
30040
T
T
12

FIG. 132

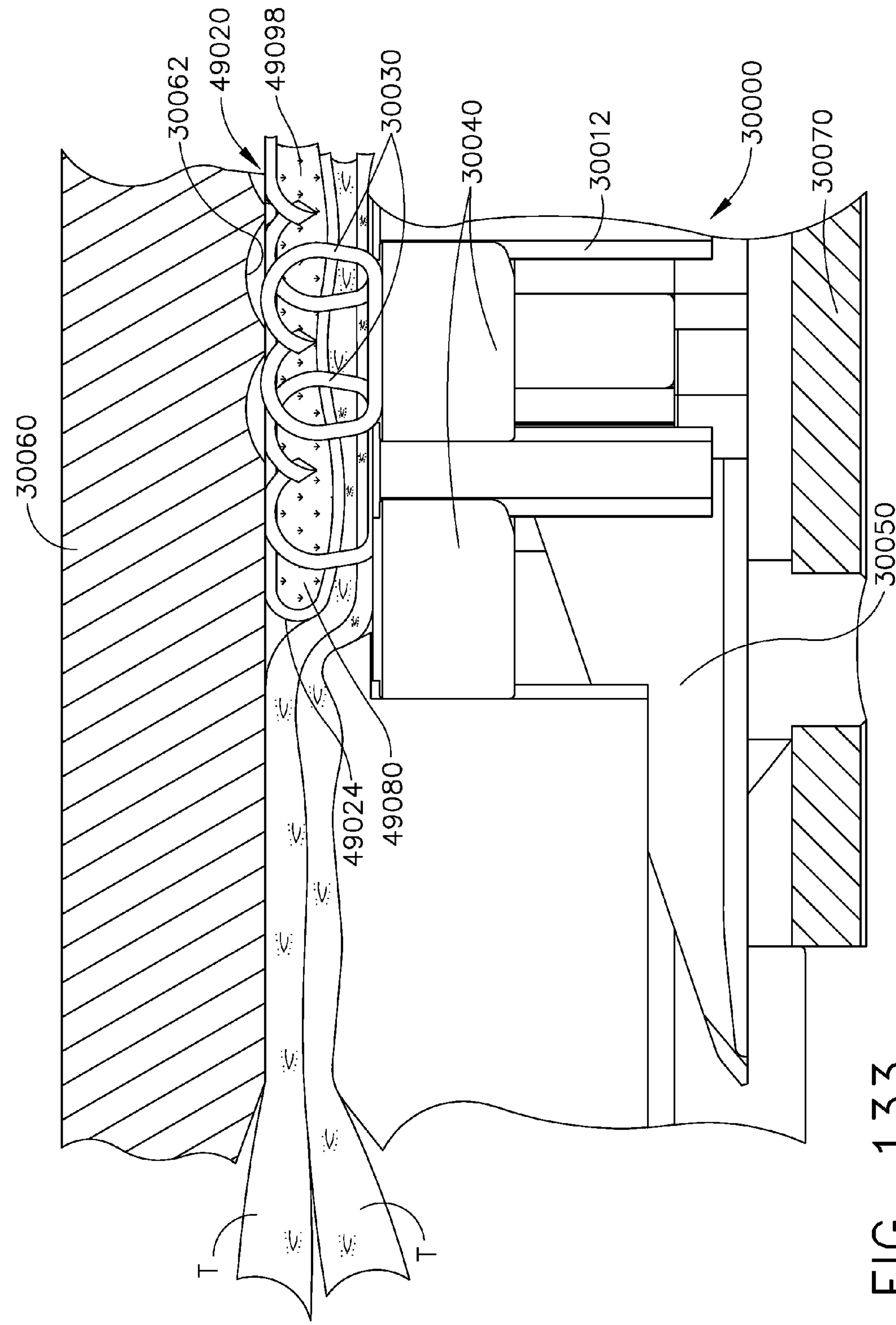

30060
30062
49020
49098
30030
30040
30012
30000
30070
30050
49024
49080
T
T

FIG. 133

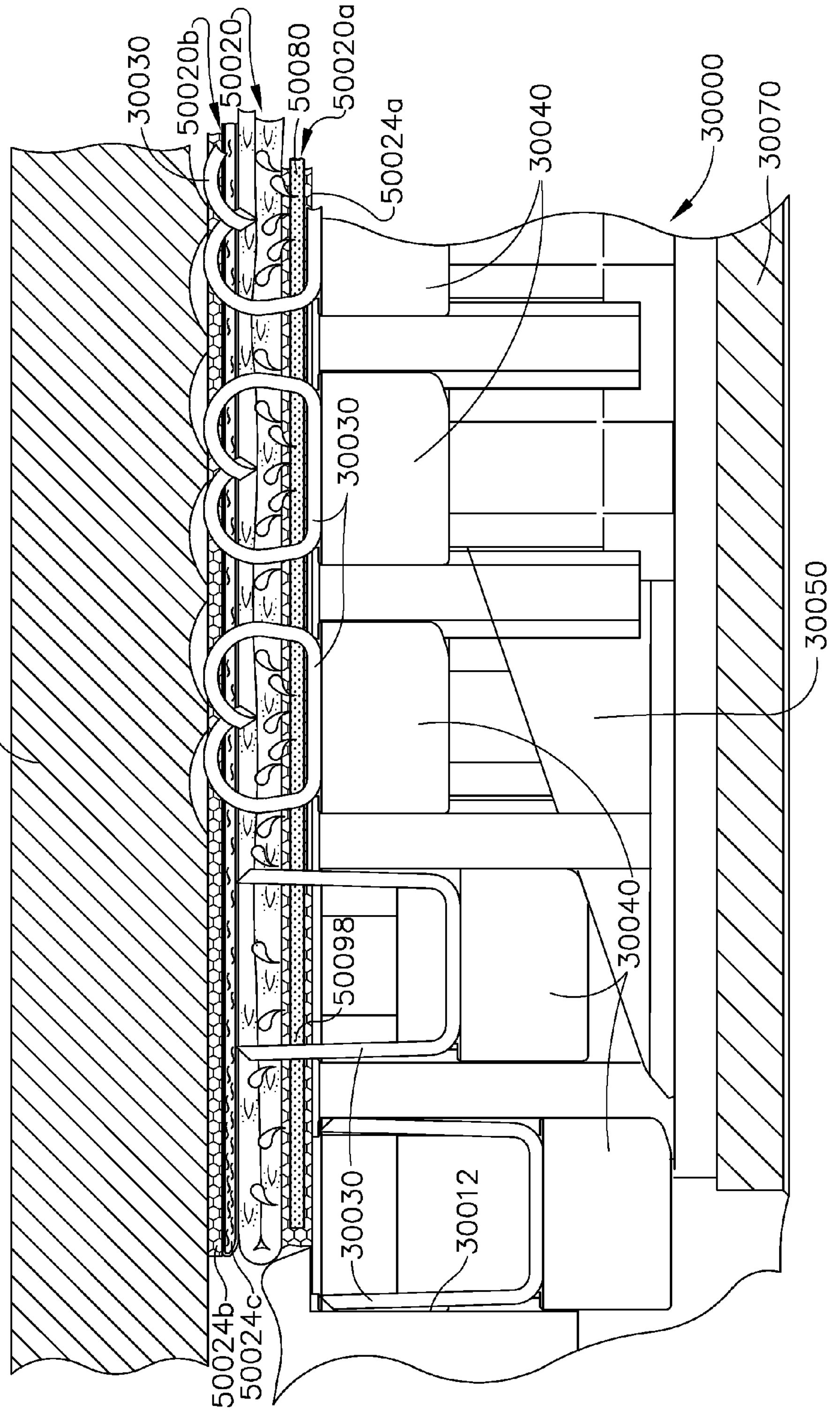

30030
50020b
50020
50080
50020a
50024a
30040
30000
30070
30060
30030
30050
30040
50098
30030
30012
50024b
50024c

FIG. 134

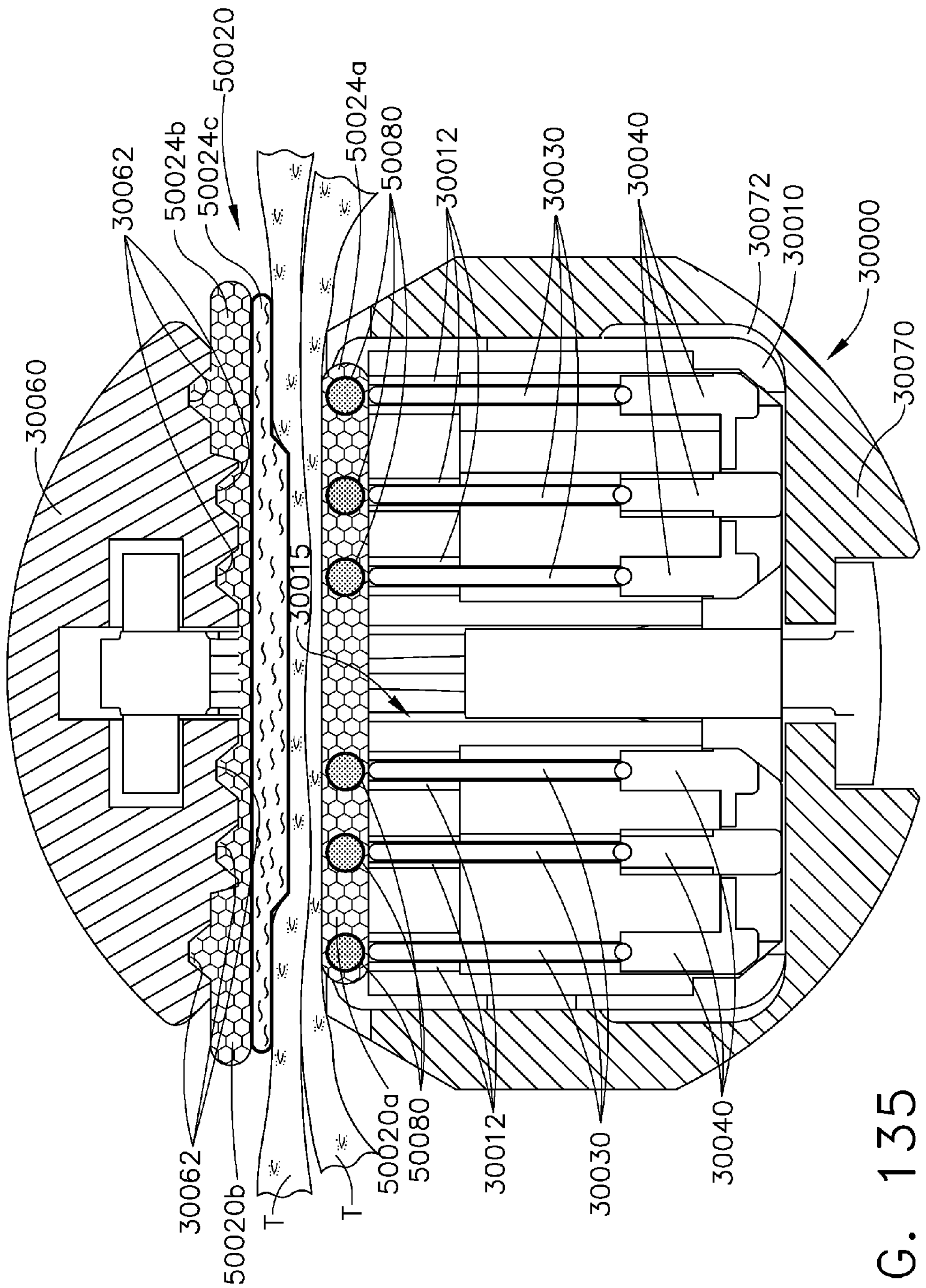

30062
50024b
50024c
50020
50024a
50080
30012
30030
30040
30072
30010
30000
30070
30060
30015
30062
50020b
T
T
50020a
50080
30012
30030
30040

FIG. 135

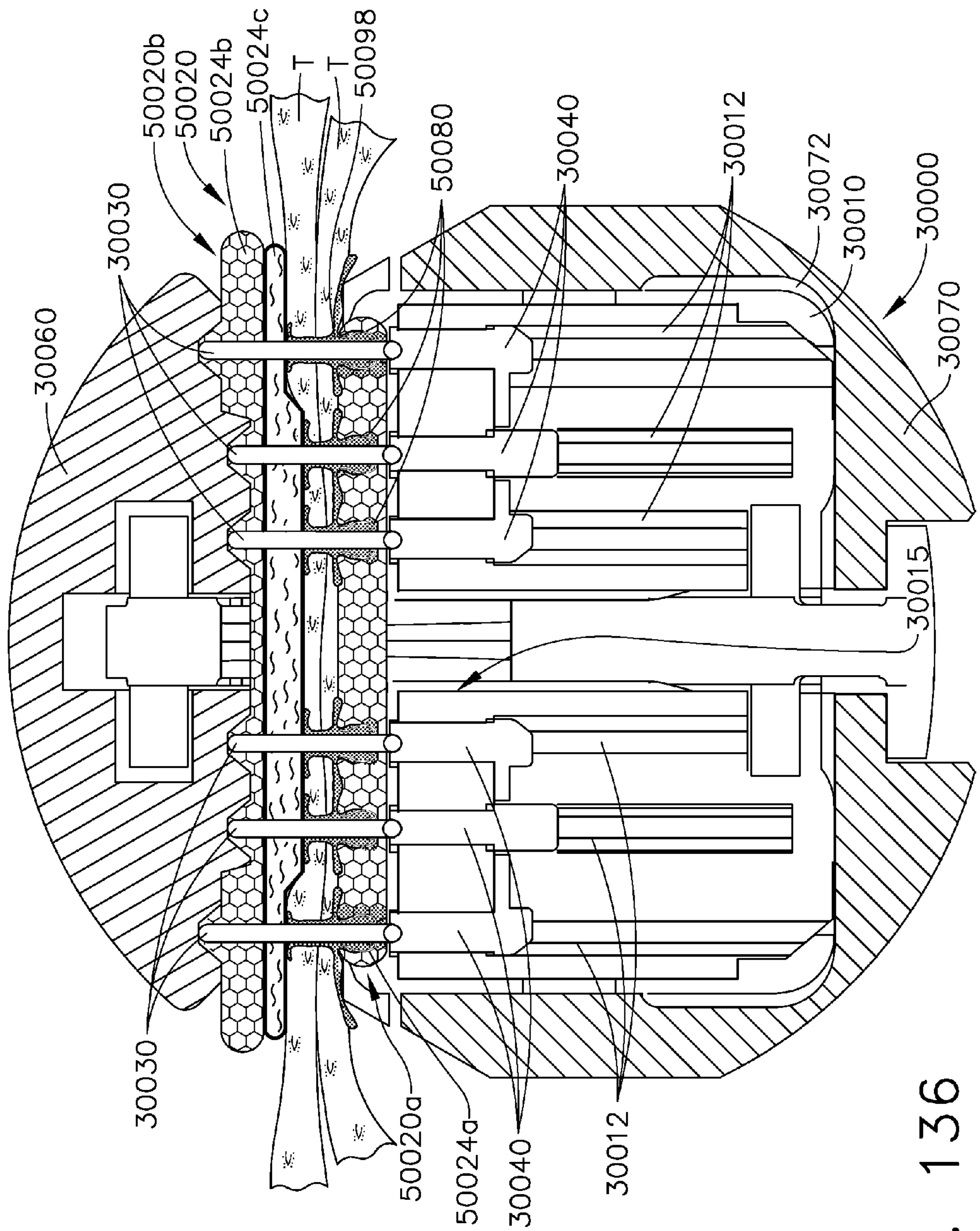
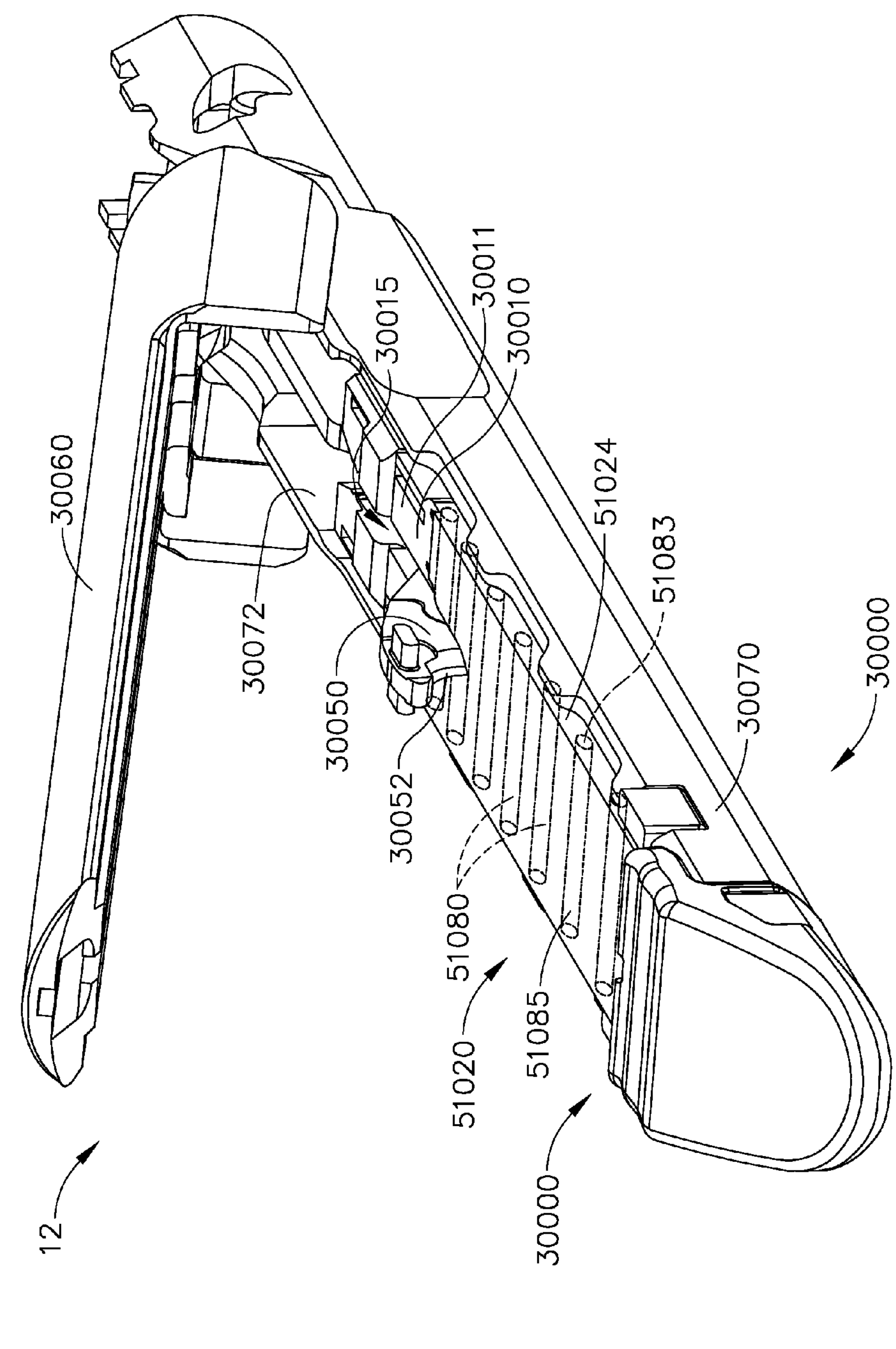

50020b
50020
50024b
50024c
T
T
50098
50080
30030
30060
30040
30012
30072
30010
30000
30070
30015
30030
50020a
50024a
30040
30012

FIG. 136



30060
30015
30011
30010
51024
51083
30072
30050
30052
30070
30000
51080
51020
51085
30000
12

FIG. 137

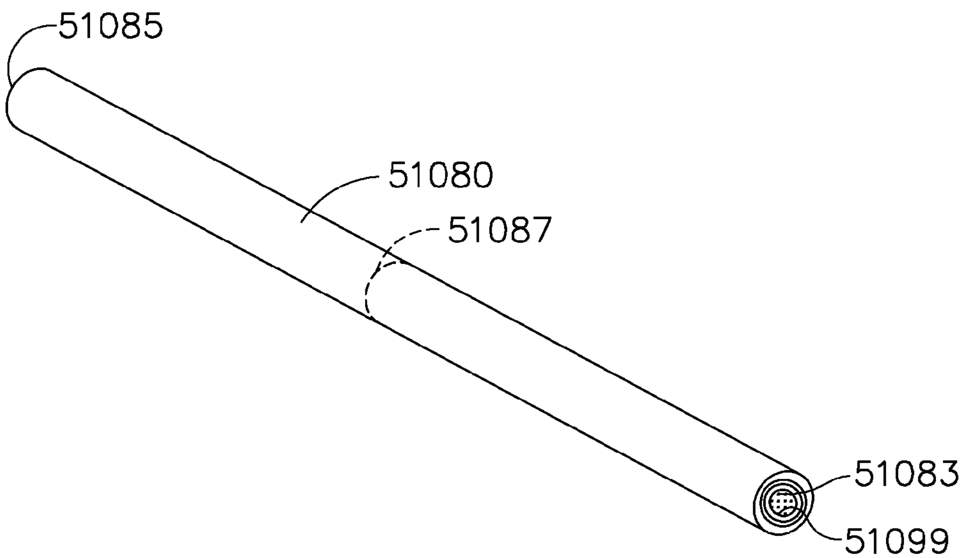


FIG. 138

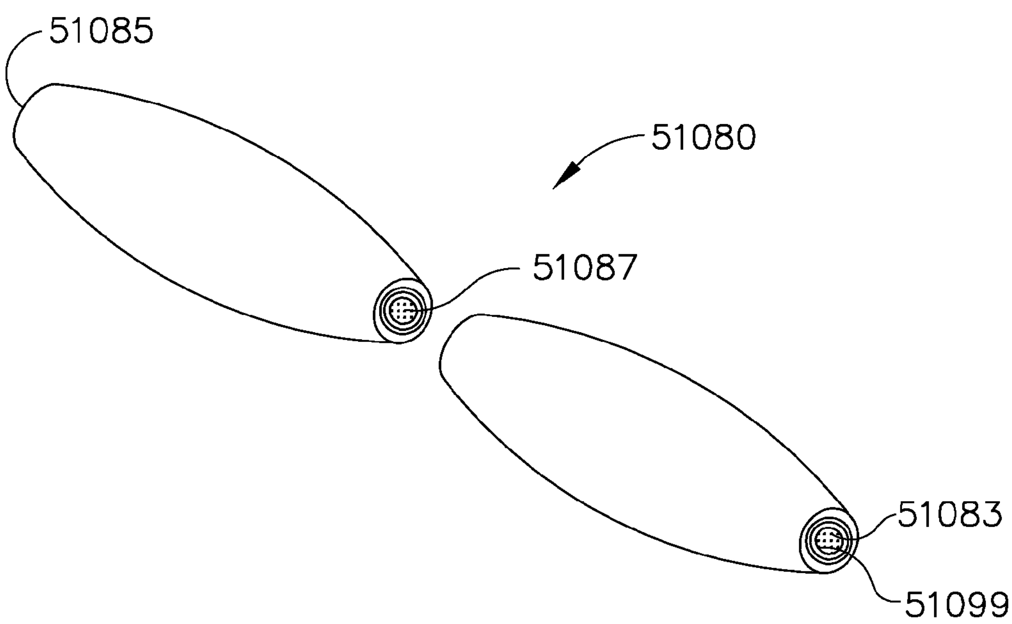


FIG. 139

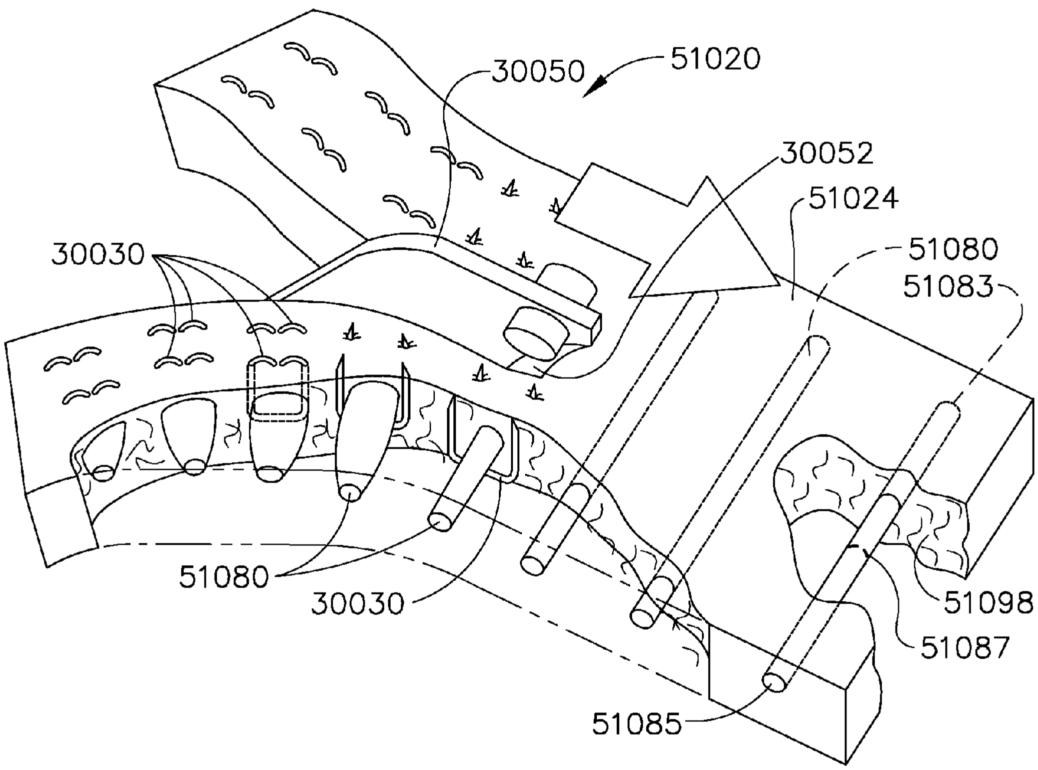

51020
30050
30052
51024
51080
51083
30030
51080
30030
51098
51087
51085

FIG. 140

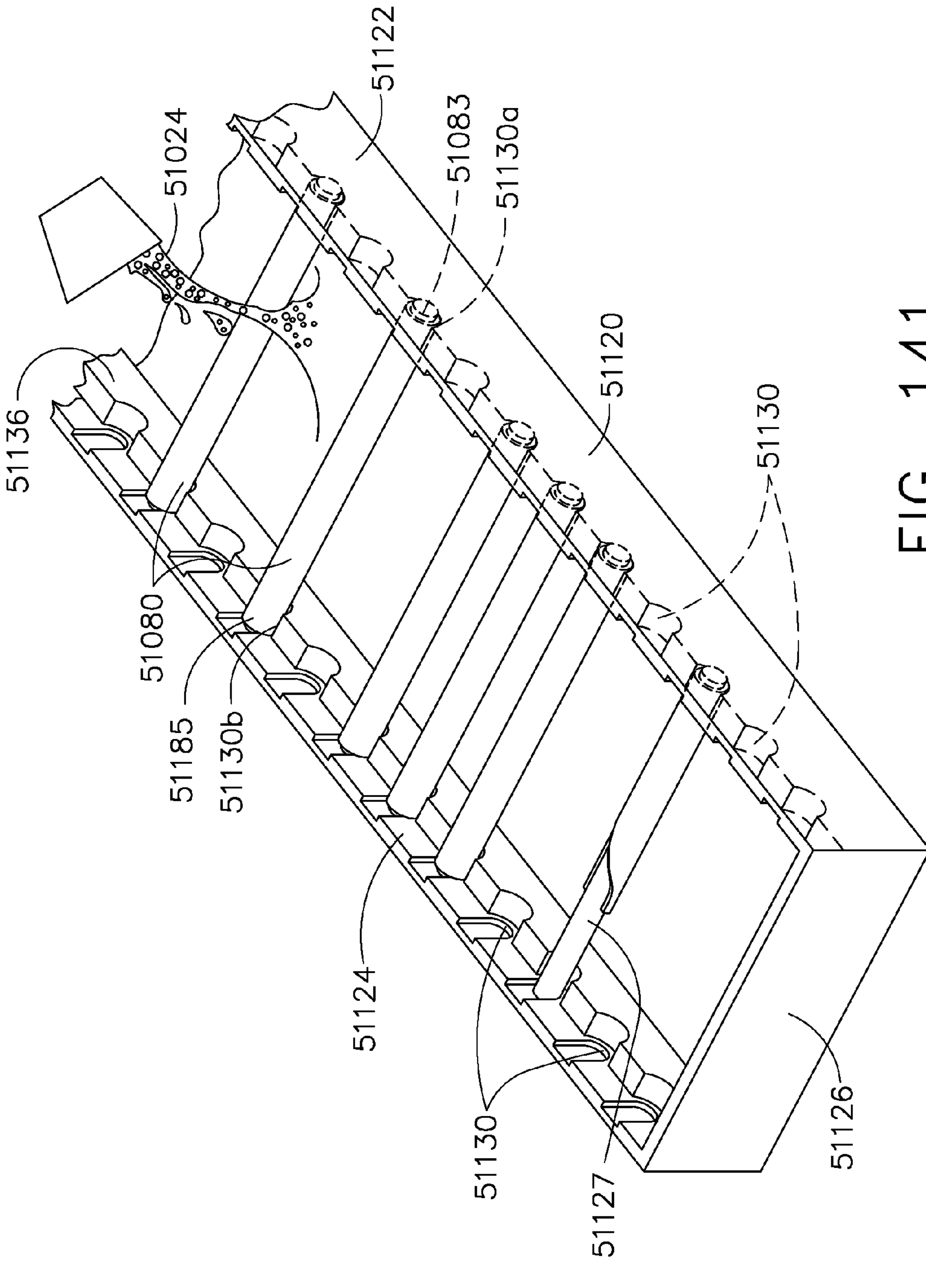

51122
51024
51083
51130a
51120
51136
51130
51080
51185
51130b
51124
51130
51127
51126

FIG. 141

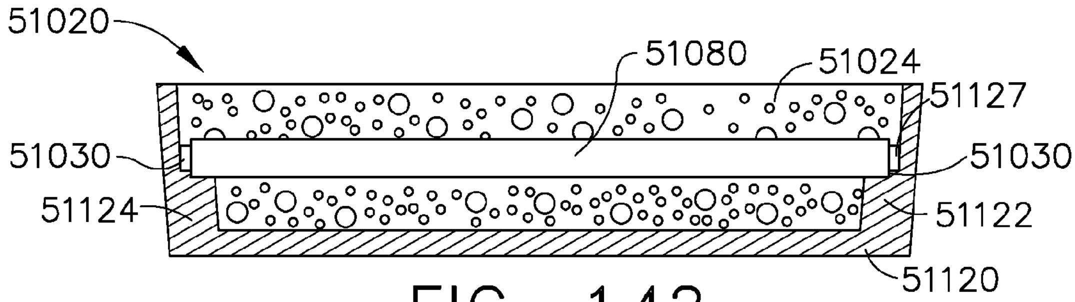


FIG. 142

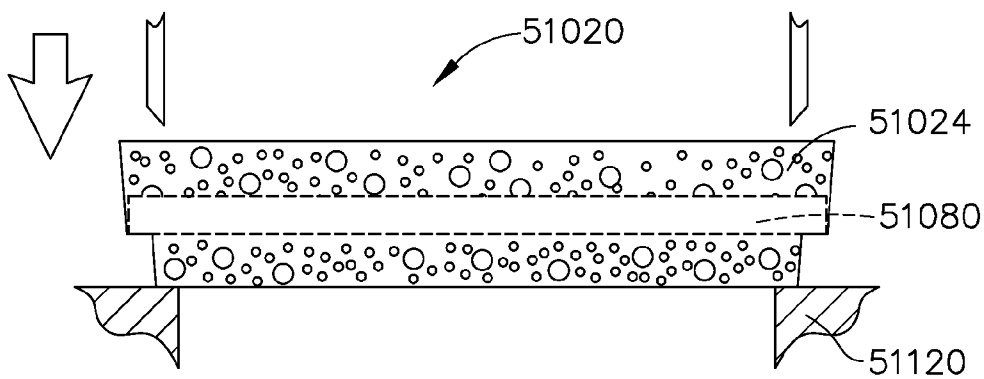


FIG. 143

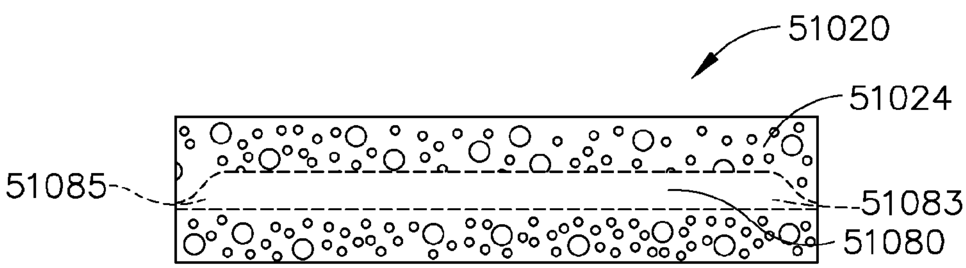


FIG. 144

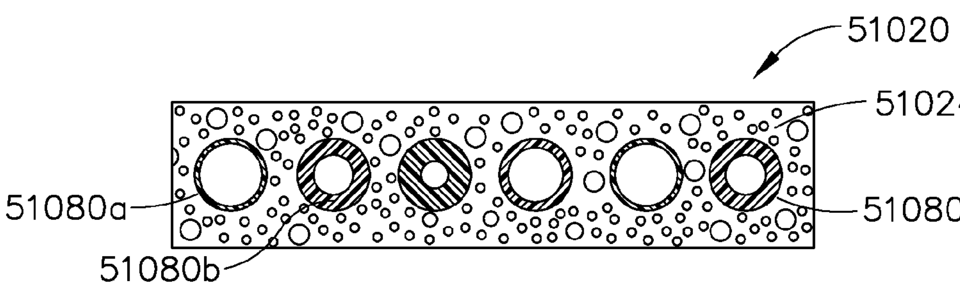


FIG. 145

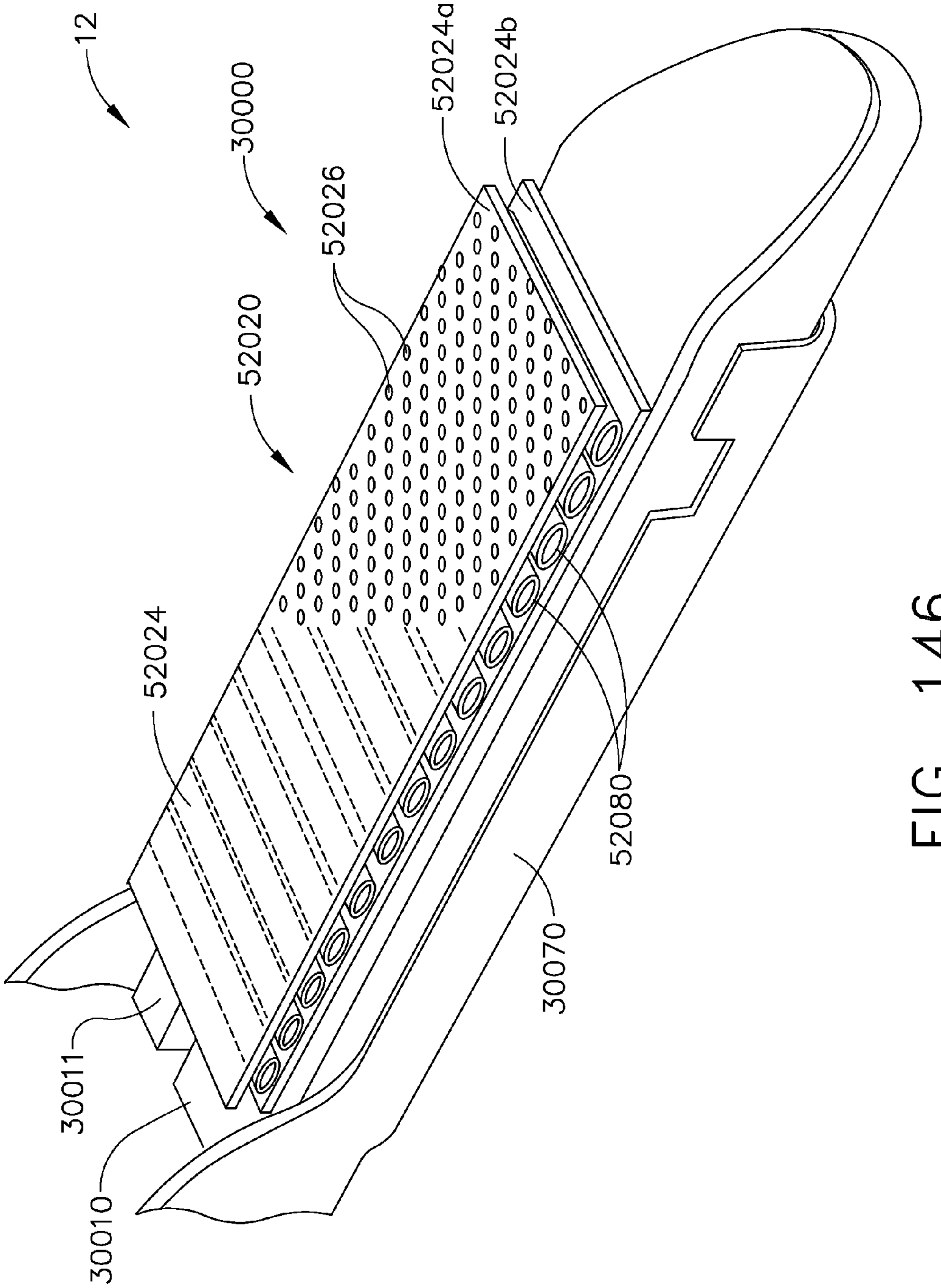

12
30000
52026
52020
52024a
52024b
52024
52080
30070
30011
30010

FIG. 146

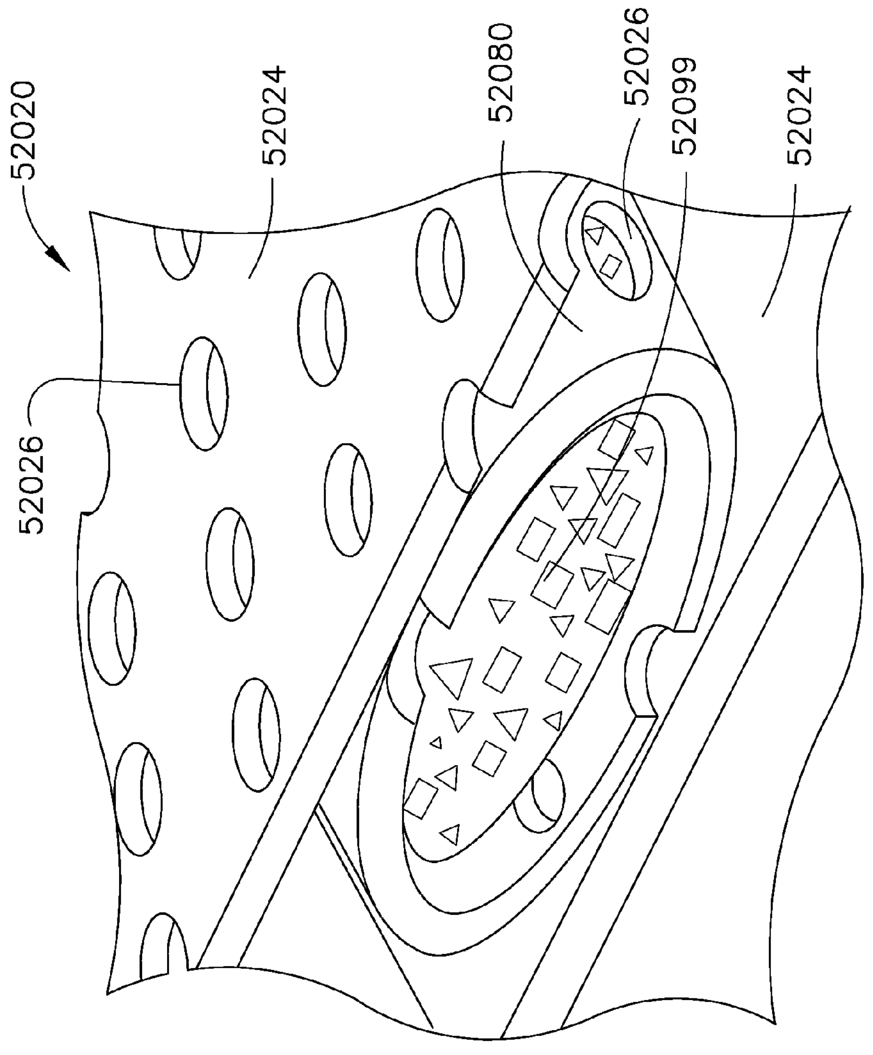


FIG. 147

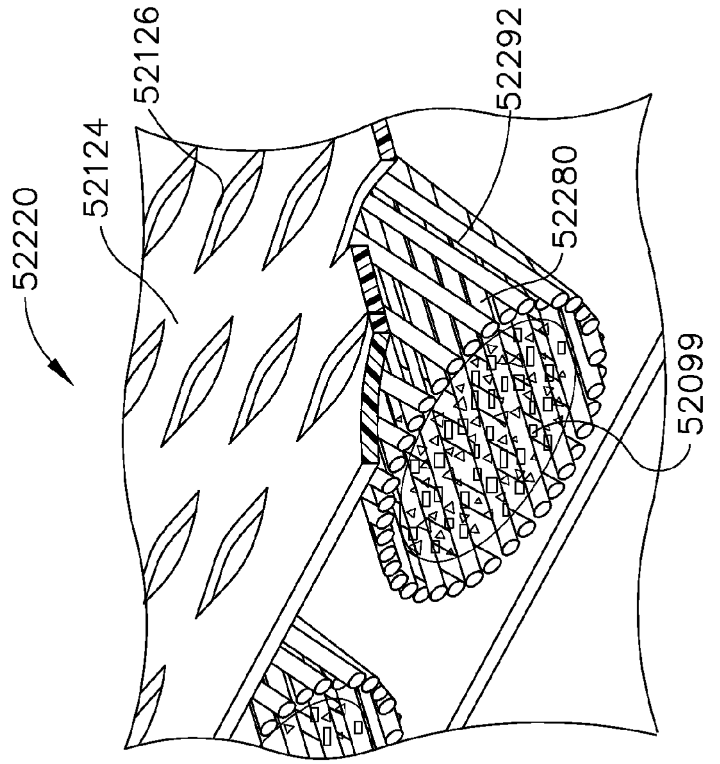


FIG. 149

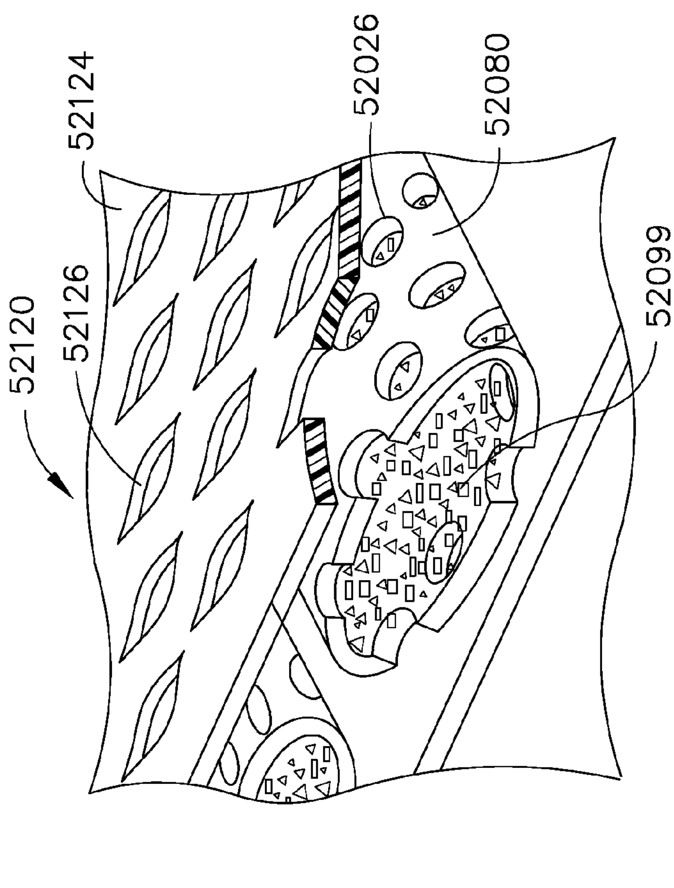


FIG. 148

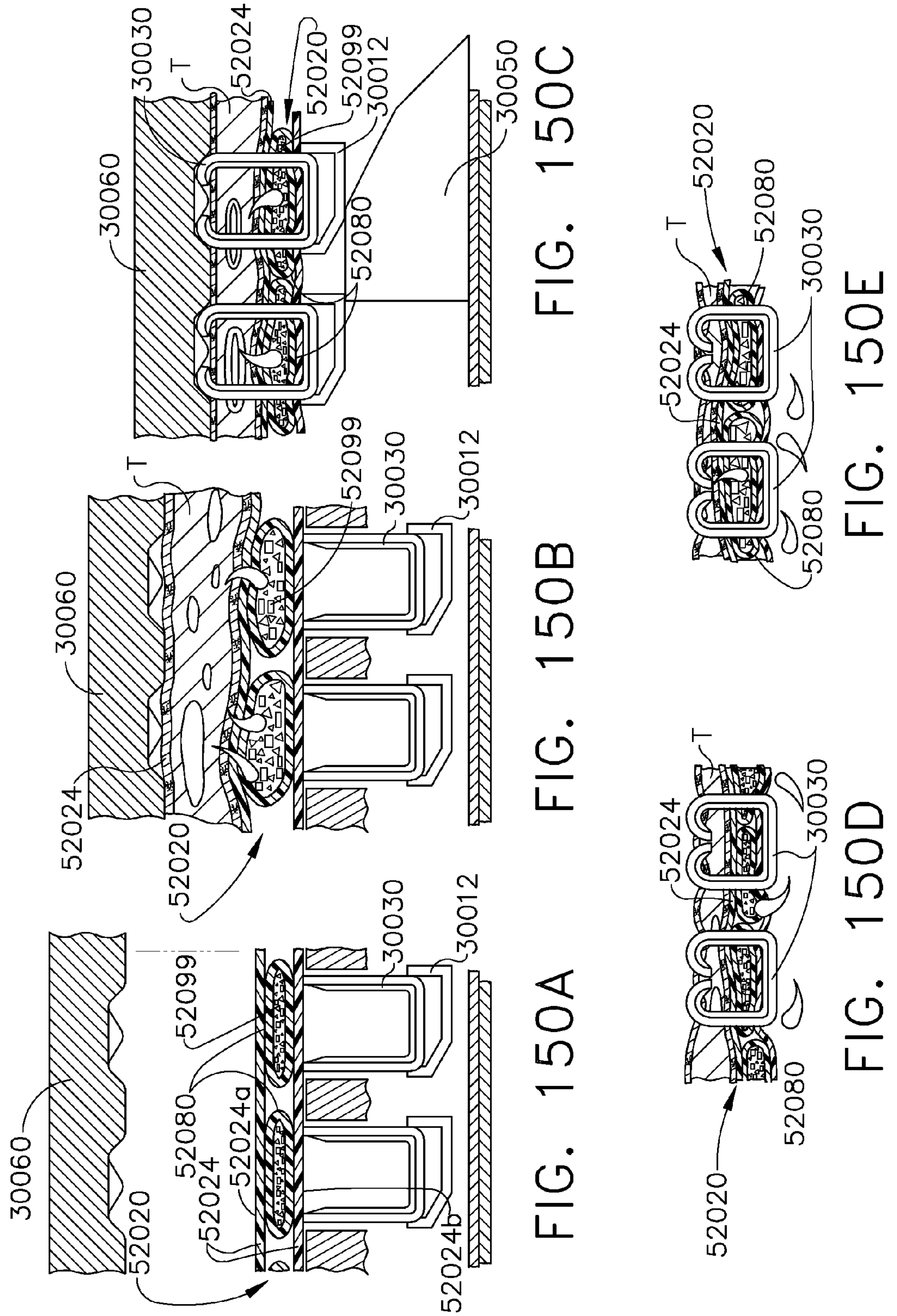


FIG. 150A

FIG. 150B

FIG. 150C

FIG. 150D

FIG. 150E

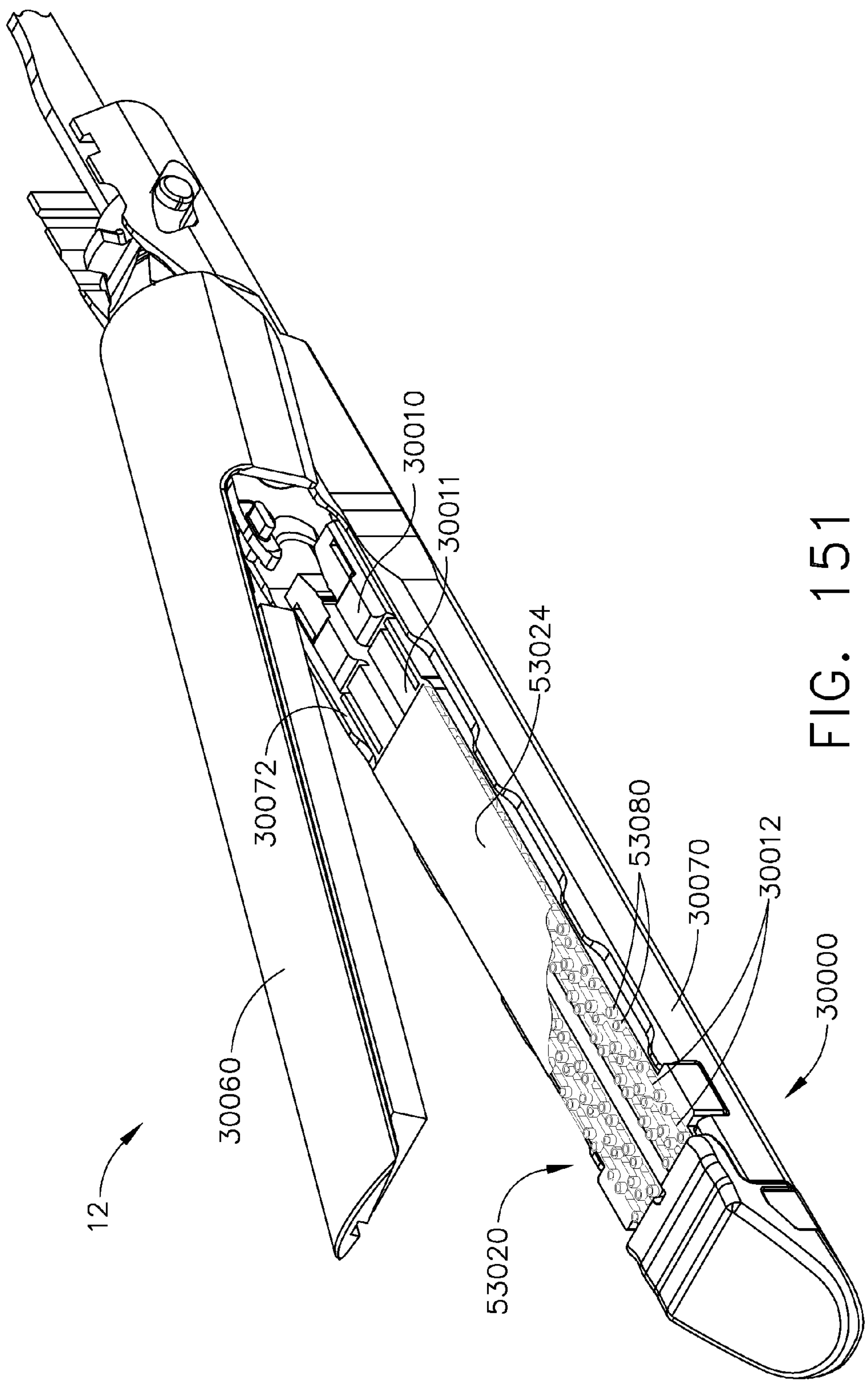

30010
30011
53024
30072
53080
30070
30012
30000
30060
12
53020

FIG. 151

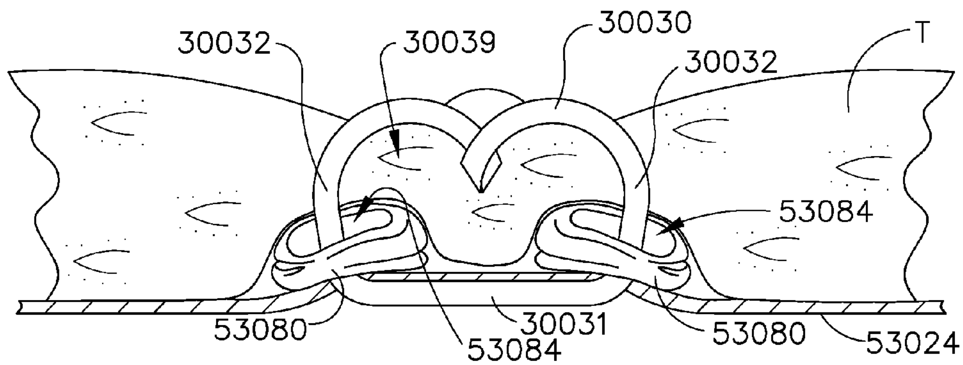


FIG. 152

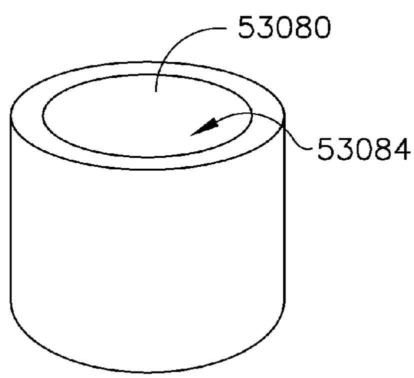


FIG. 153

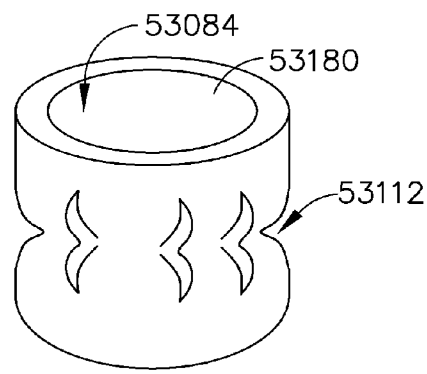


FIG. 154

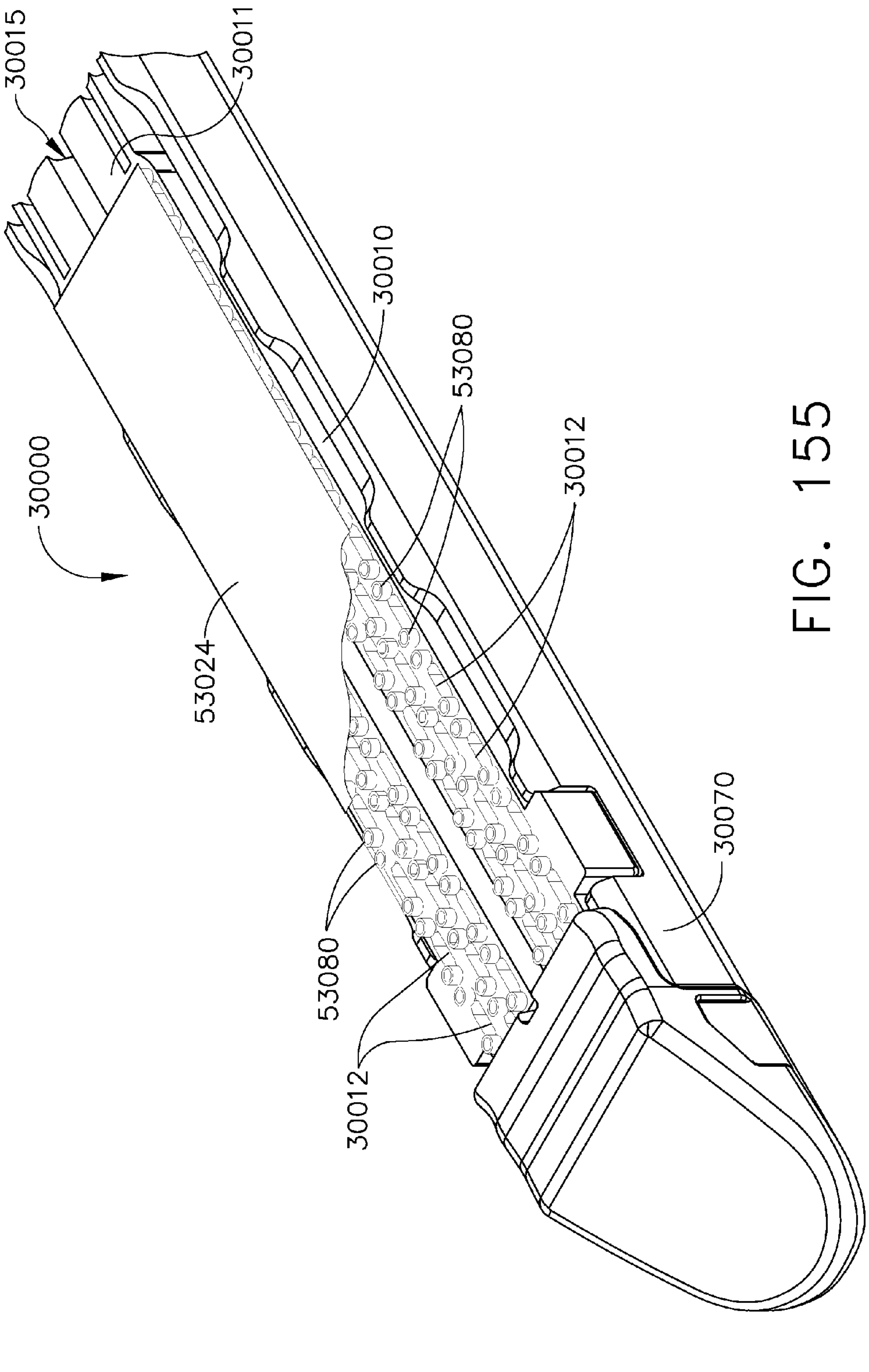

30015
30011
30010
53080
30012
30000
53024
30070
53080
30012

FIG. 155

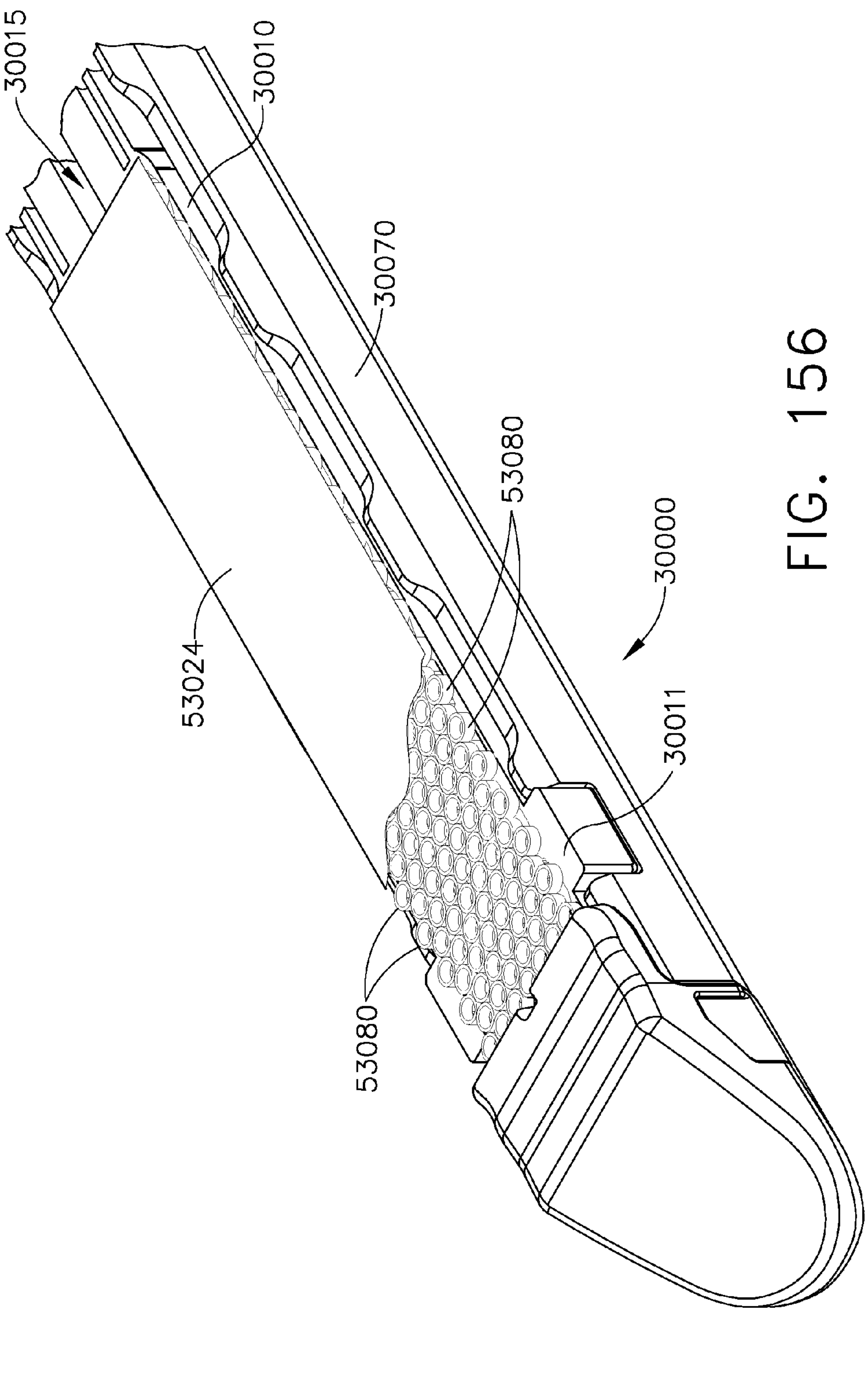


FIG. 156

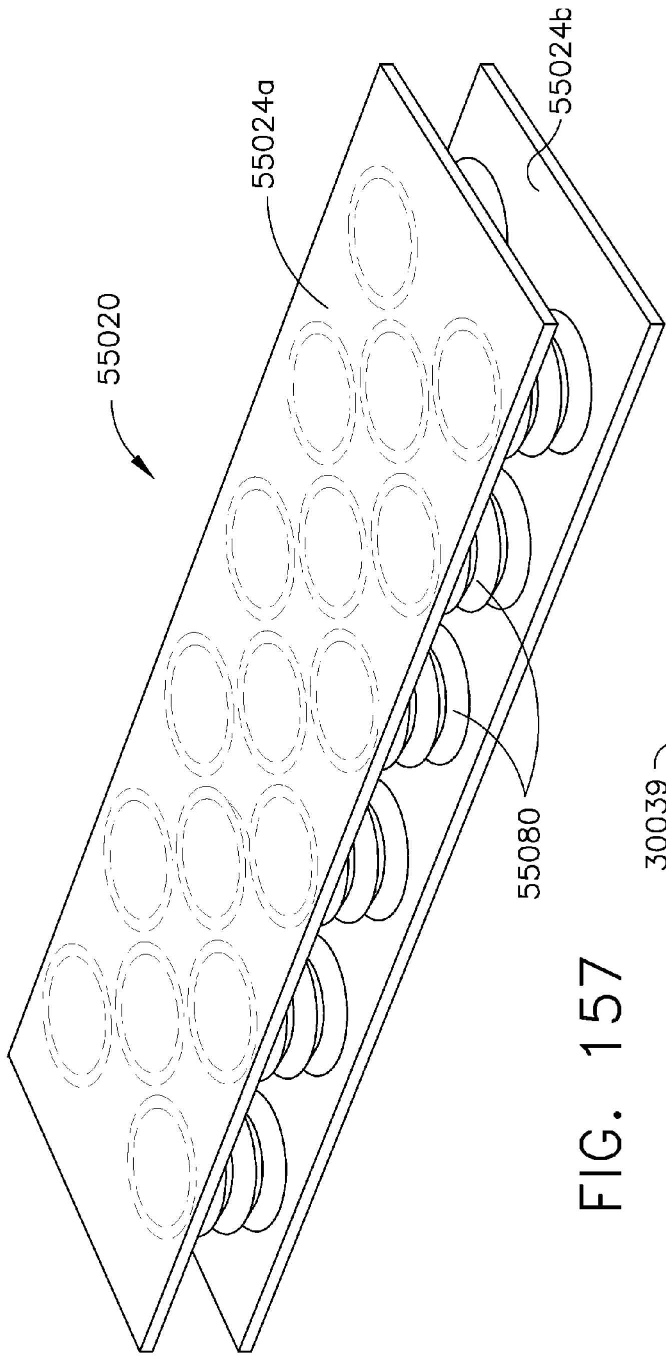


FIG. 157

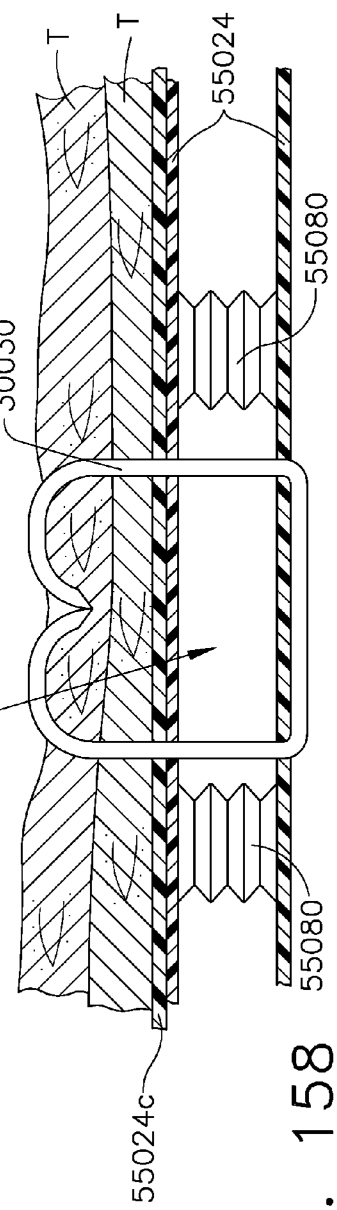


FIG. 158

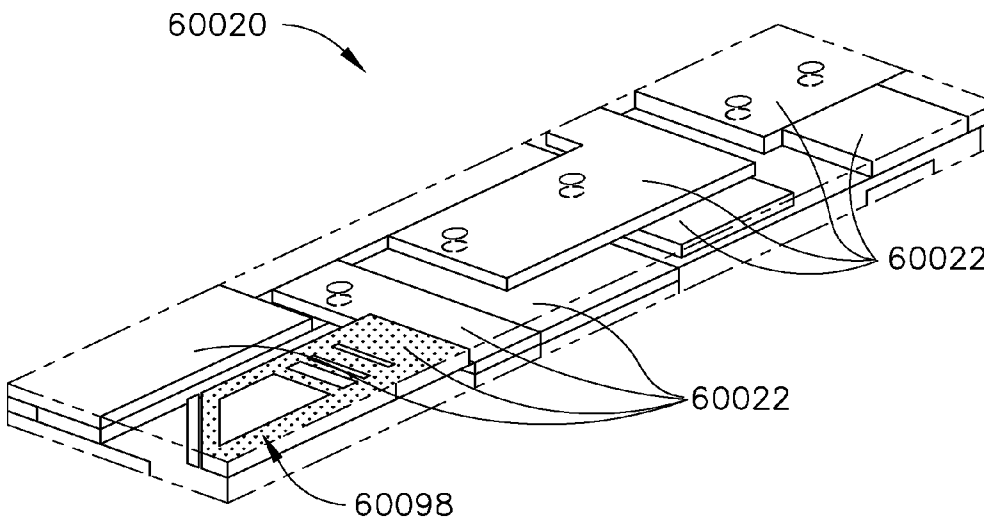


FIG. 159

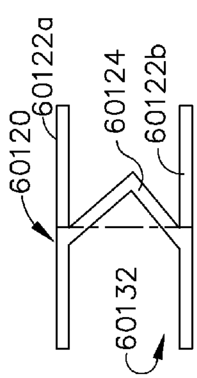


FIG. 160

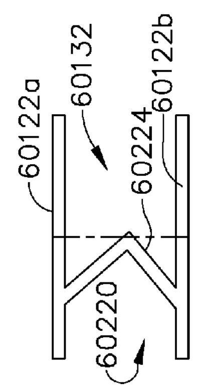


FIG. 161

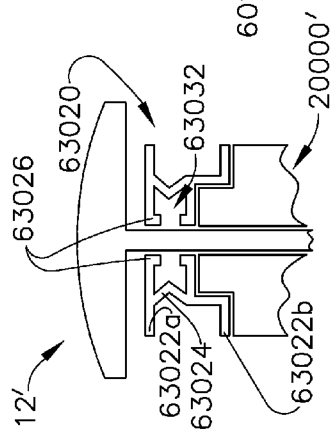


FIG. 162

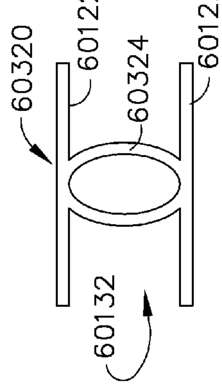


FIG. 163

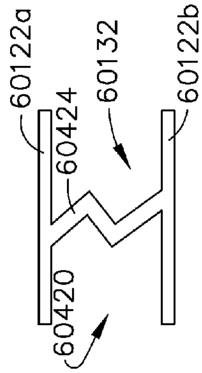


FIG. 164

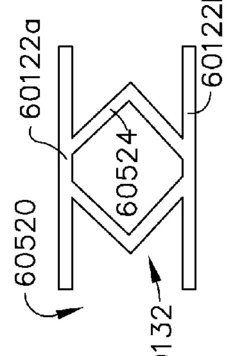


FIG. 165

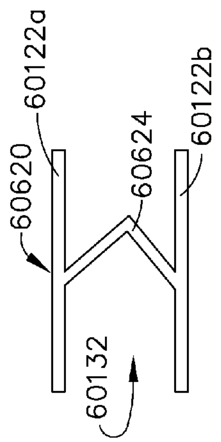


FIG. 166

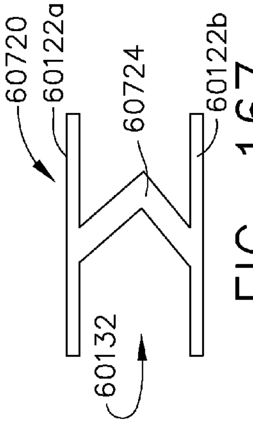


FIG. 167

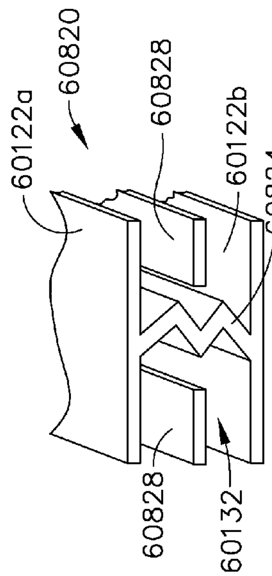


FIG. 168

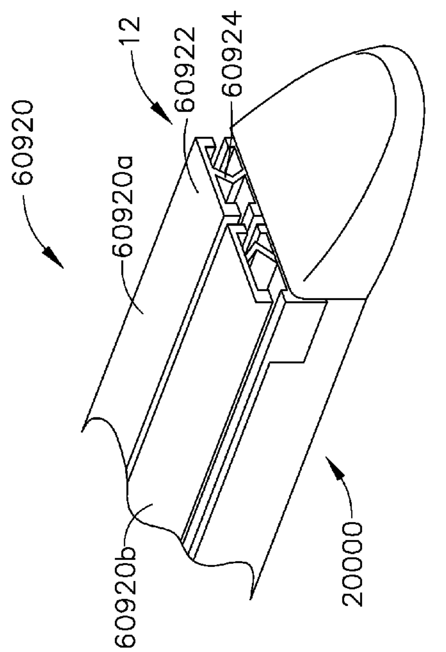


FIG. 169

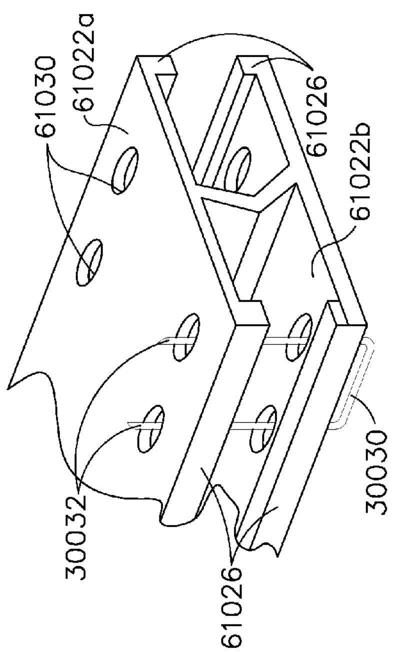


FIG. 170

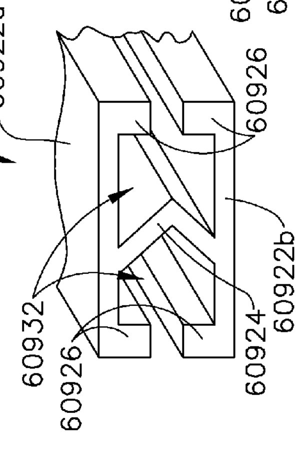


FIG. 171

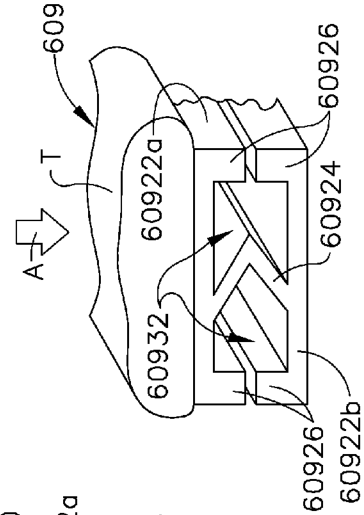


FIG. 172

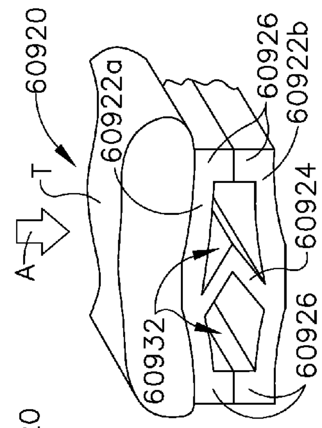


FIG. 173

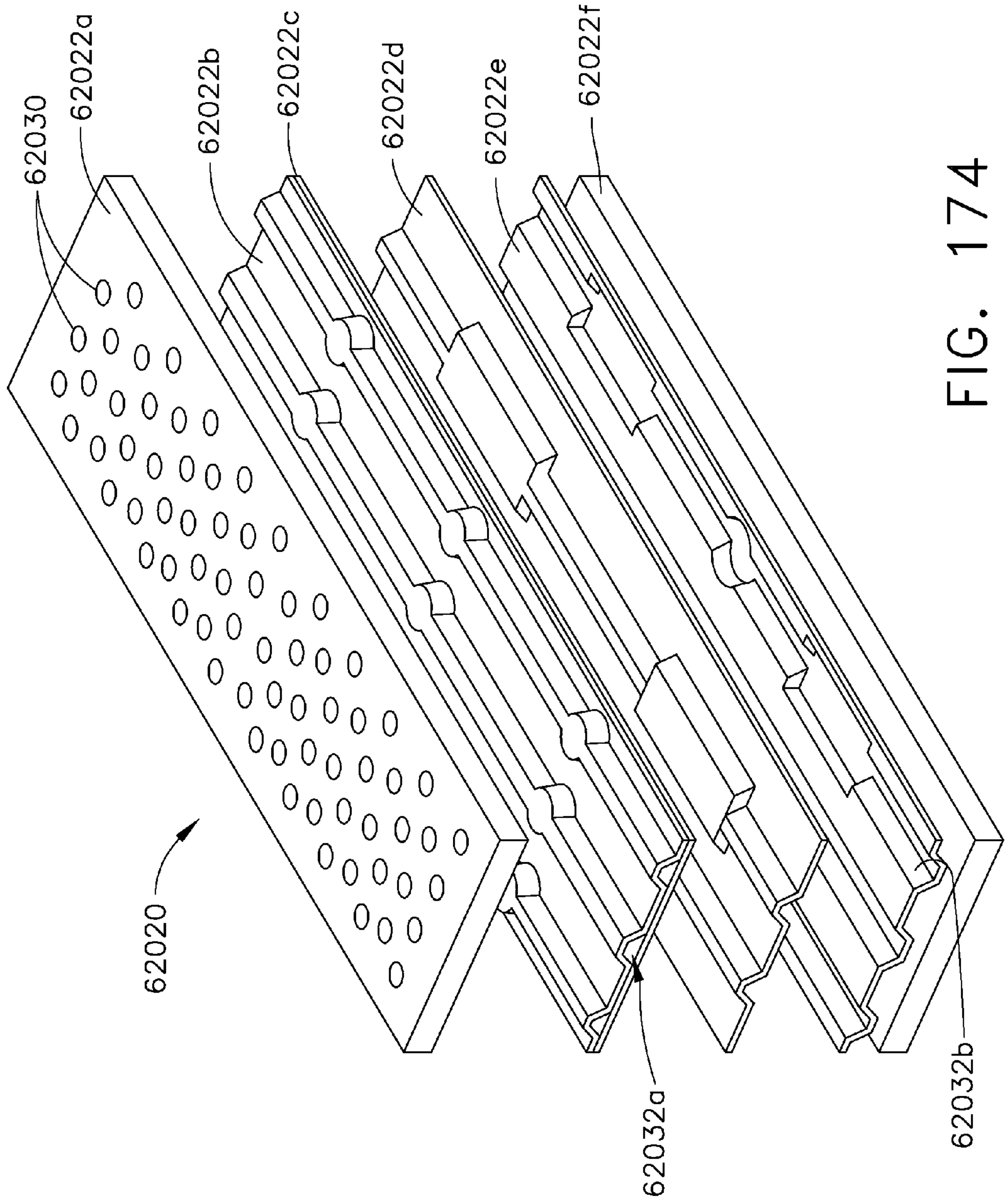

62030
62022a
62022b
62022c
62022d
62022e
62022f
62020
62032a
62032b

FIG. 174

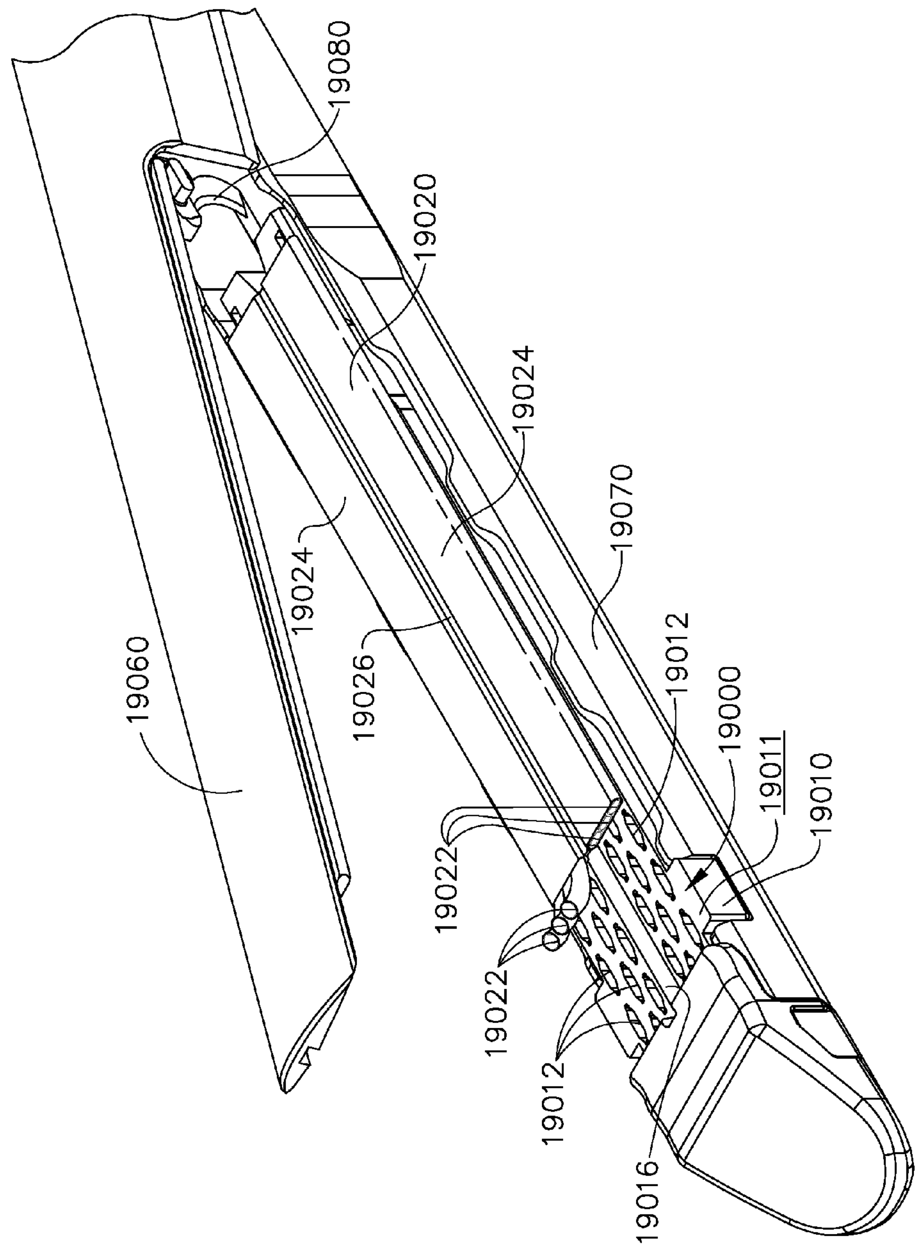

19080
19020
19024
19070
19024
19026
19060
19012
19000
19011
19010
19022
19022
19012
19016

FIG. 175

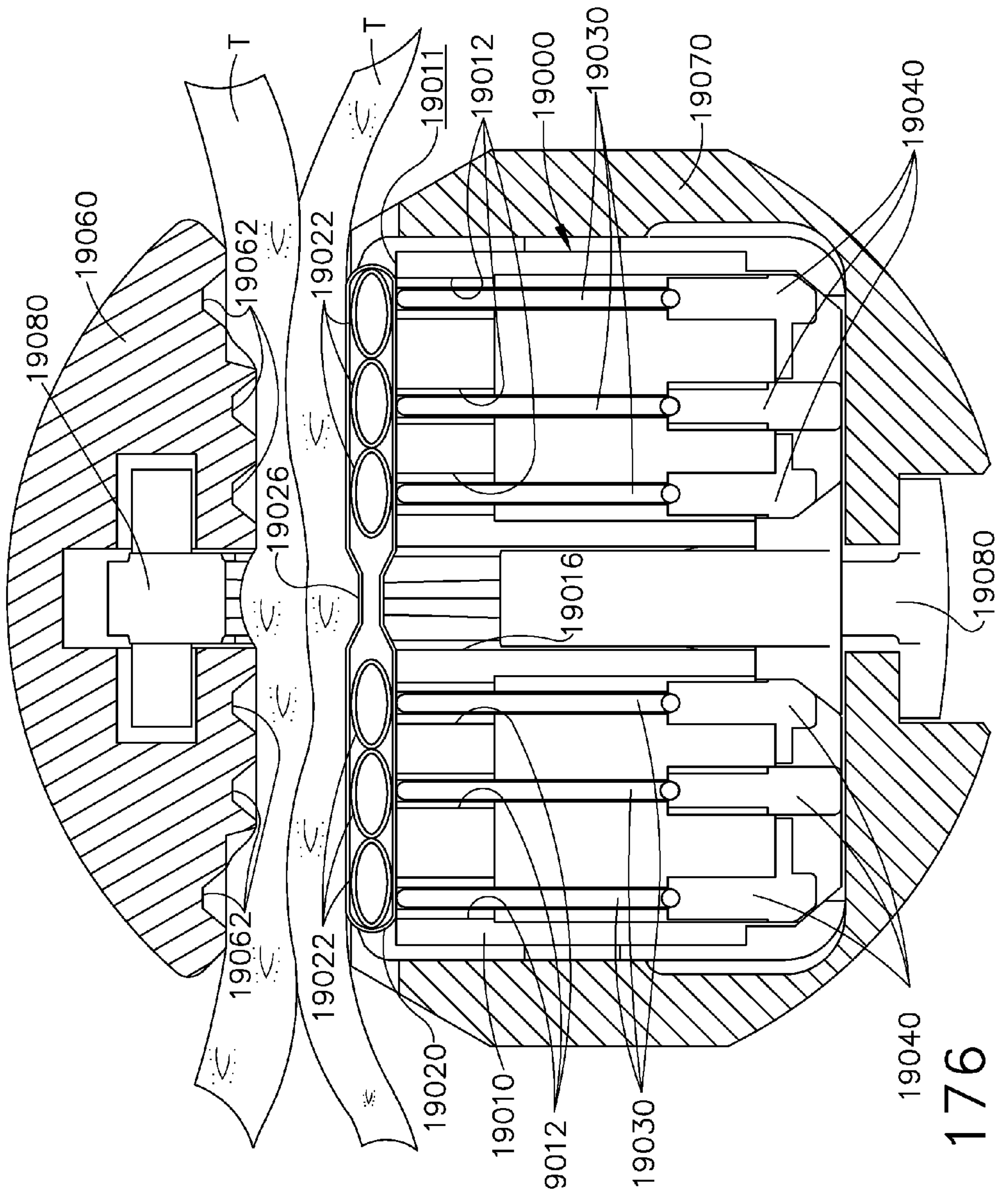

T
T
19011
19012
19000
19030
19070
19040
19060
19080
19062
19022
19026
19016
19080
19062
19022
19020
19010
19012
19030
19040

FIG. 176

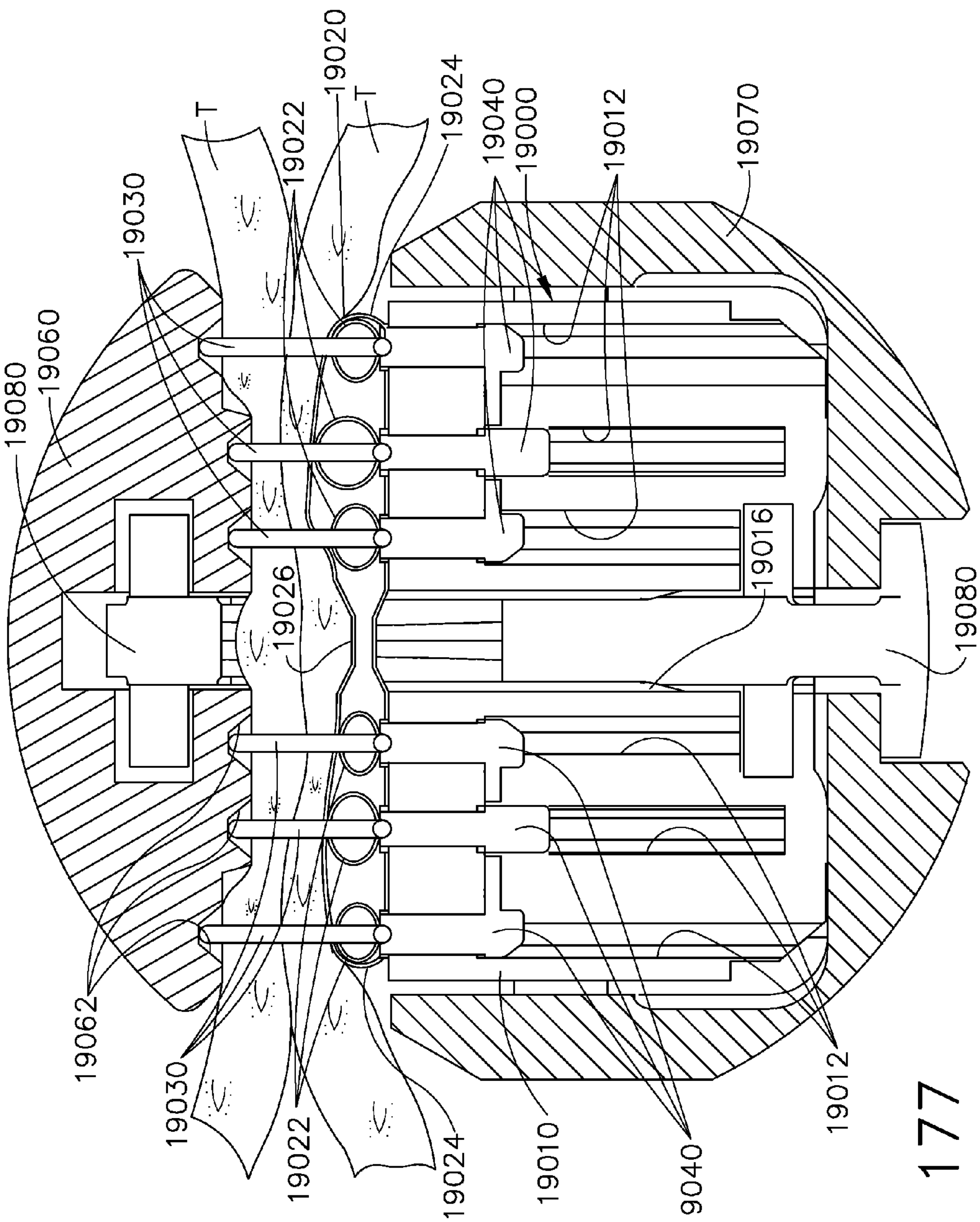

T
T
19020
19022
19024
19040
19000
19012
19070
19030
19060
19080
19016
19026
19080
19062
19030
19022
19024
19010
19040
19012

FIG. 177

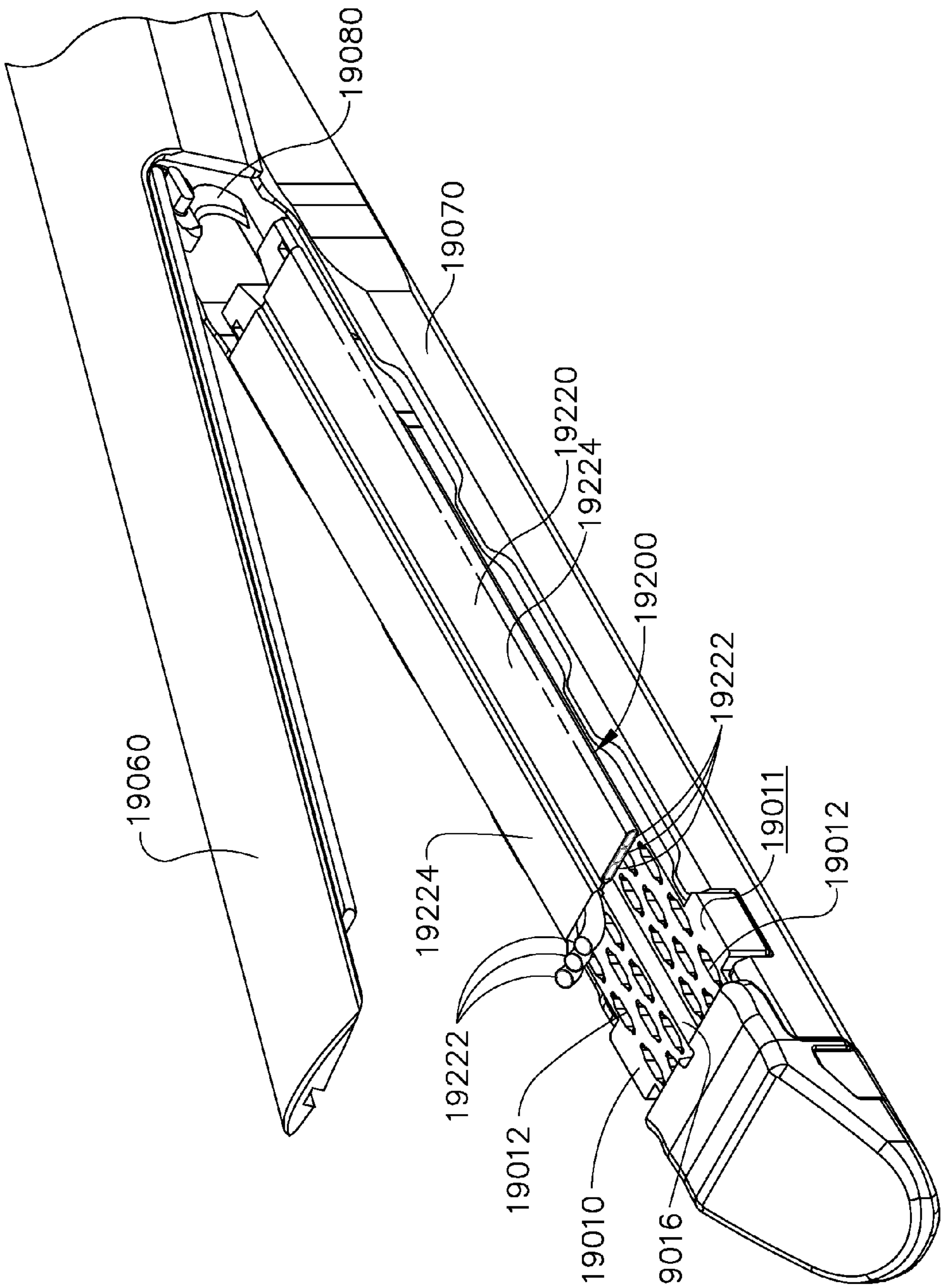

19080
19070
19220
19224
19200
19222
19011
19012
19060
19224
19222
19012
19010
19016

FIG. 178

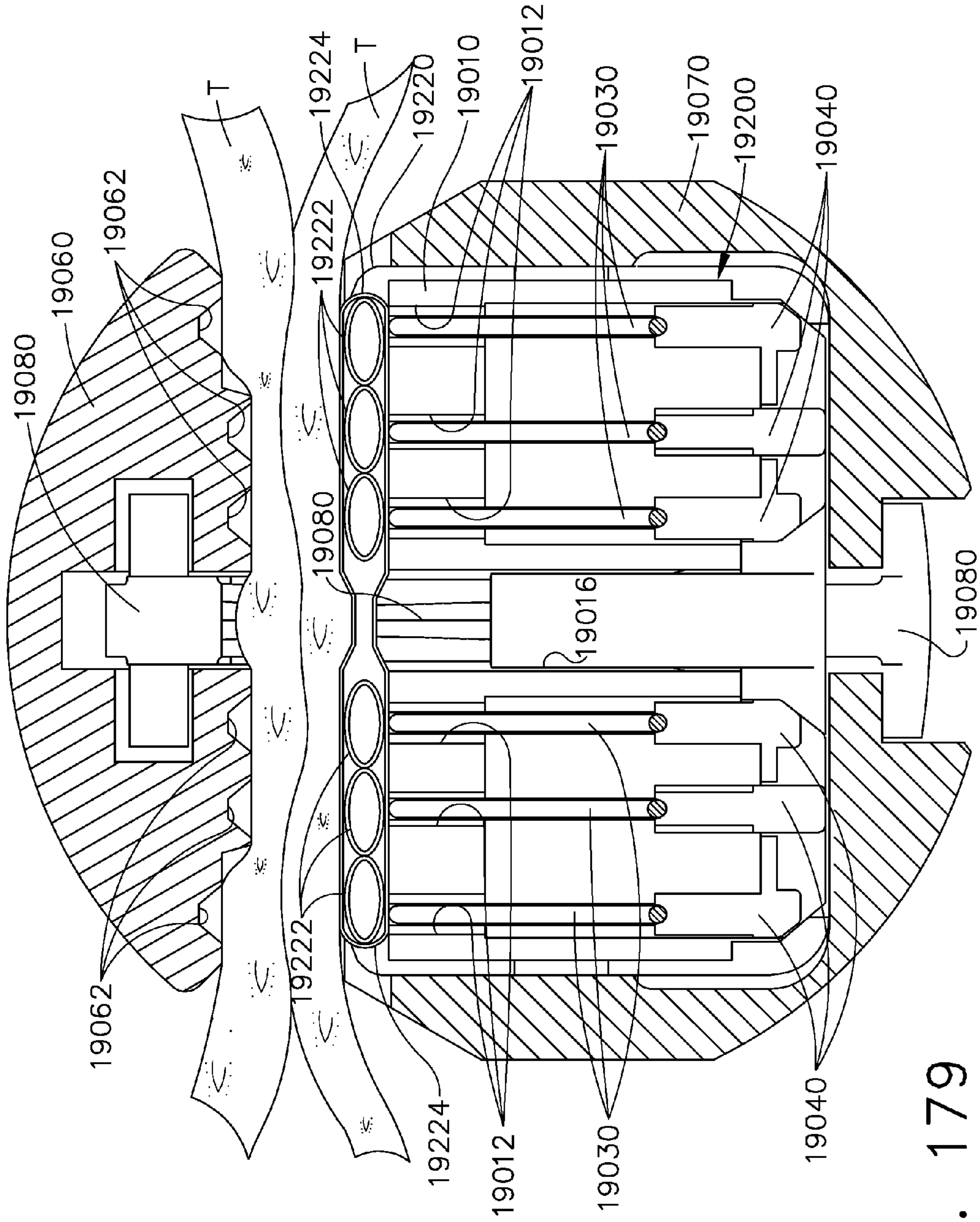
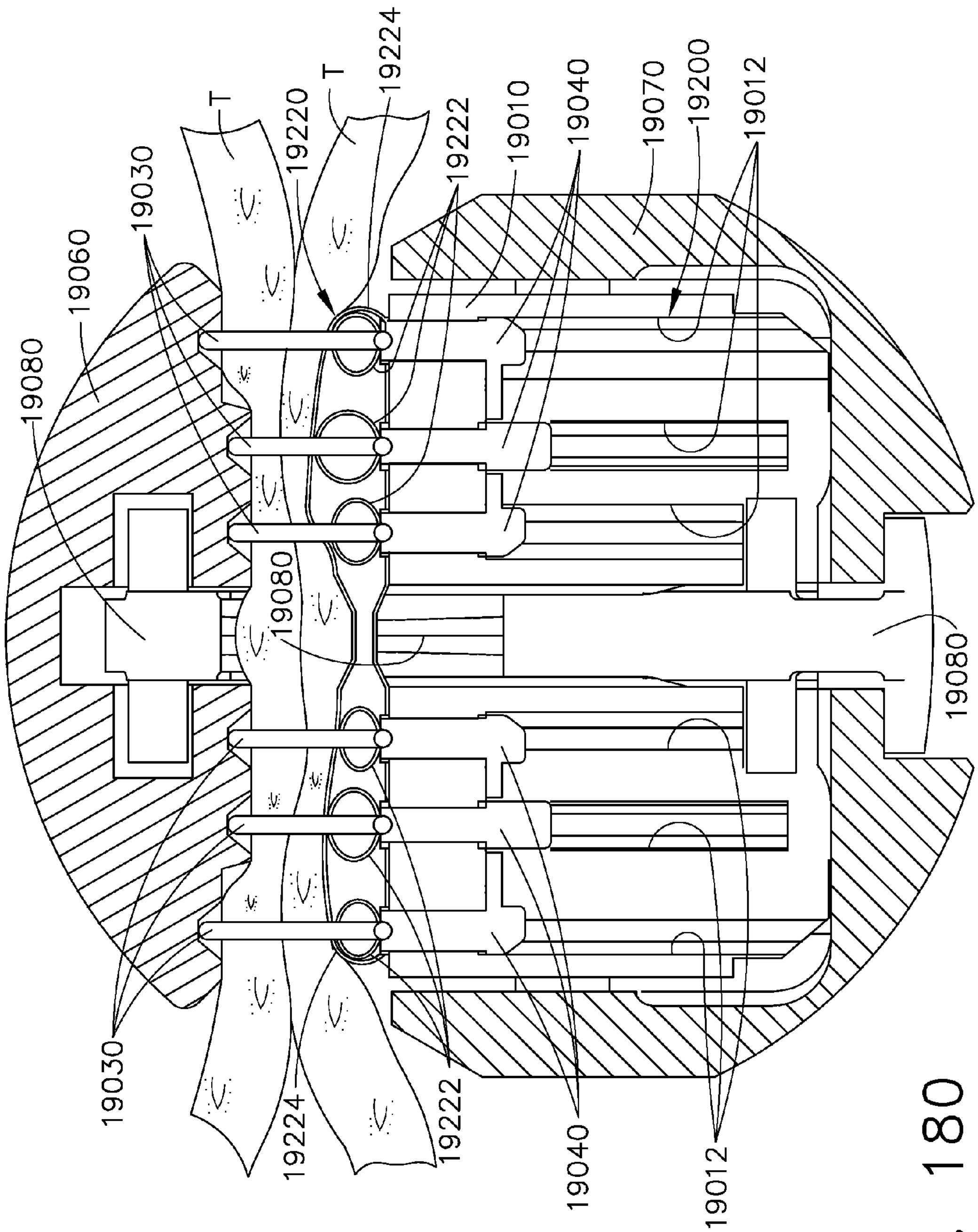

T
19224
T
19220
19010
19012
19030
19070
19200
19040
19062
19060
19222
19080
19080
19016
19080
19062
19222
19224
19012
19030
19040

FIG. 179



T
T
19224
19220
19222
19010
19040
19070
19200
19012
19030
19060
19080
19080
19080
19030
19224
19222
19040
19012

FIG. 180

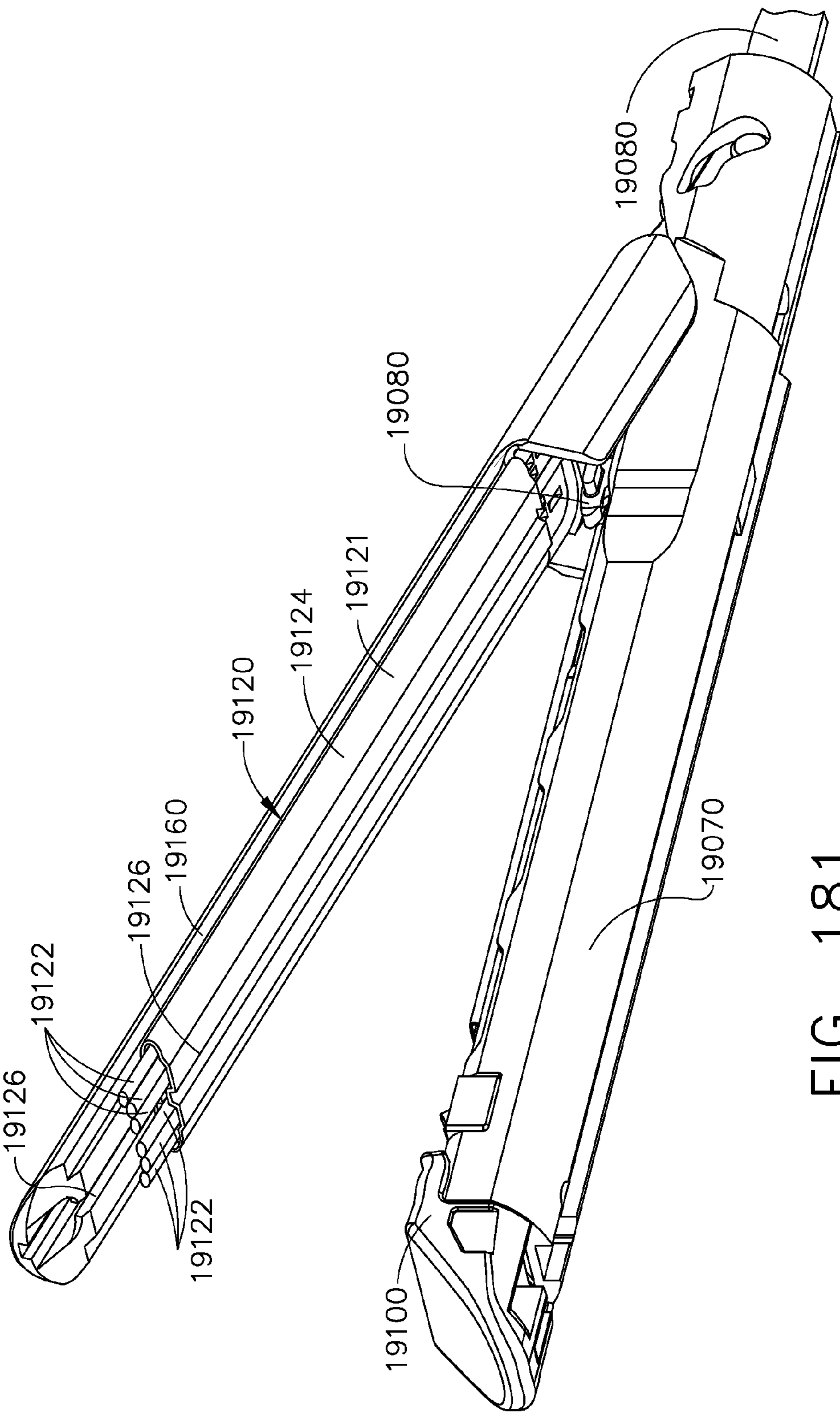

19080
19080
19121
19124
19120
19160
19126
19122
19126
19122
19070
19100

FIG. 181

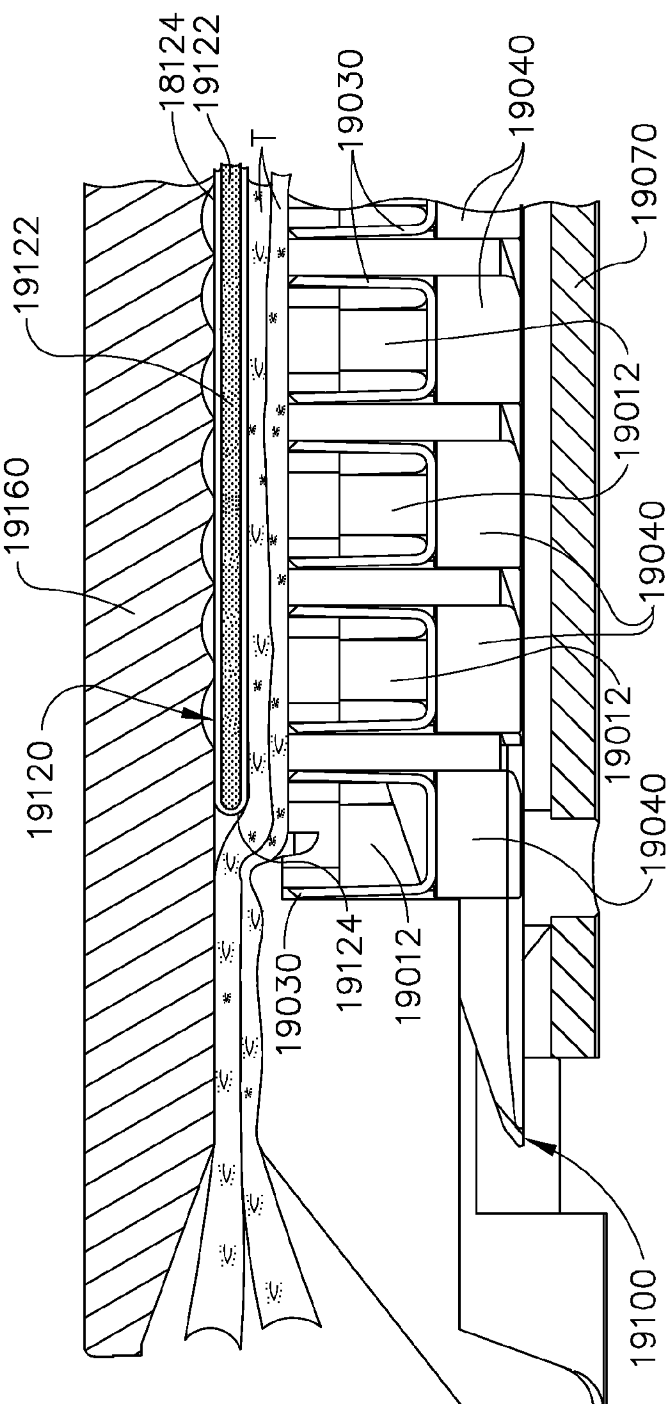

18124
19122
T
19030
19040
19070
19122
19160
19012
19040
19012
19120
19040
19124
19012
19030
19100

FIG. 182

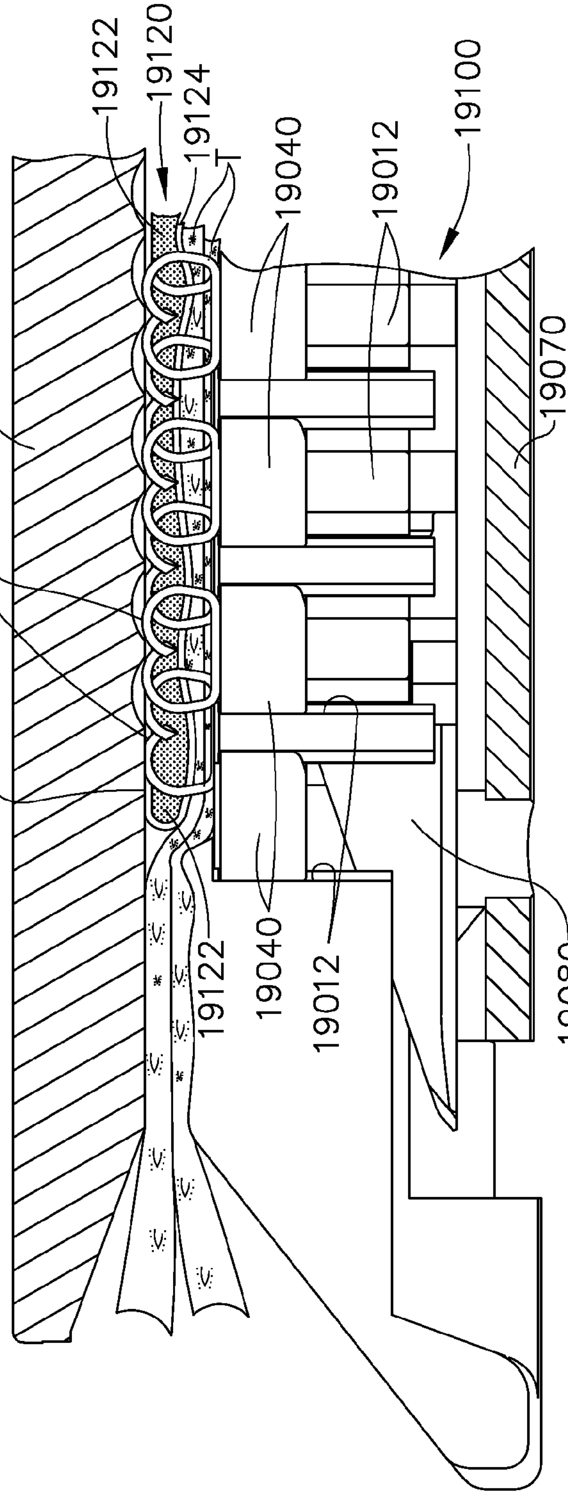

19122
19120
19124
T
19040
19012
19100
19160
19070
19030
19124
19122
19040
19012
19080

FIG. 183

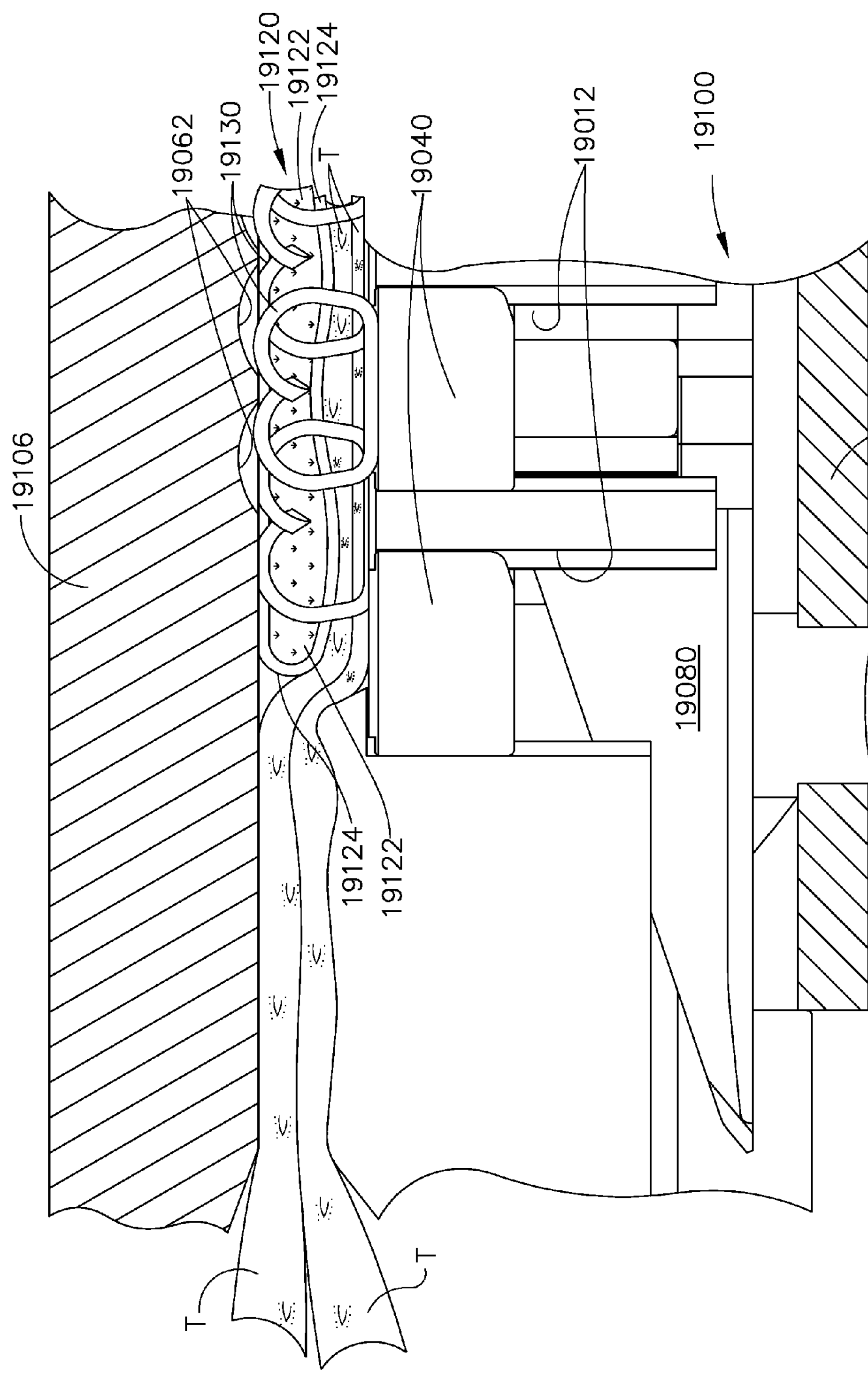

19120
19122
19124
T
19062
19130
19040
19012
19100
19106
19070
19080
19124
19122
T
T

FIG. 184

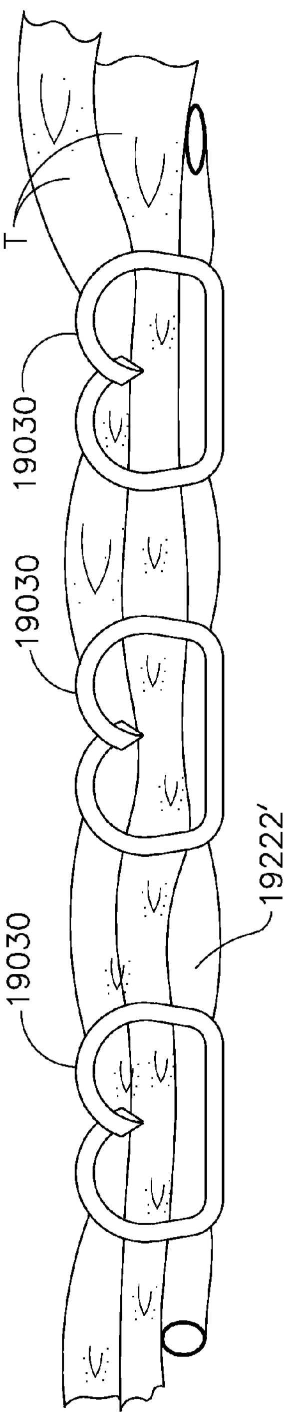


FIG. 185

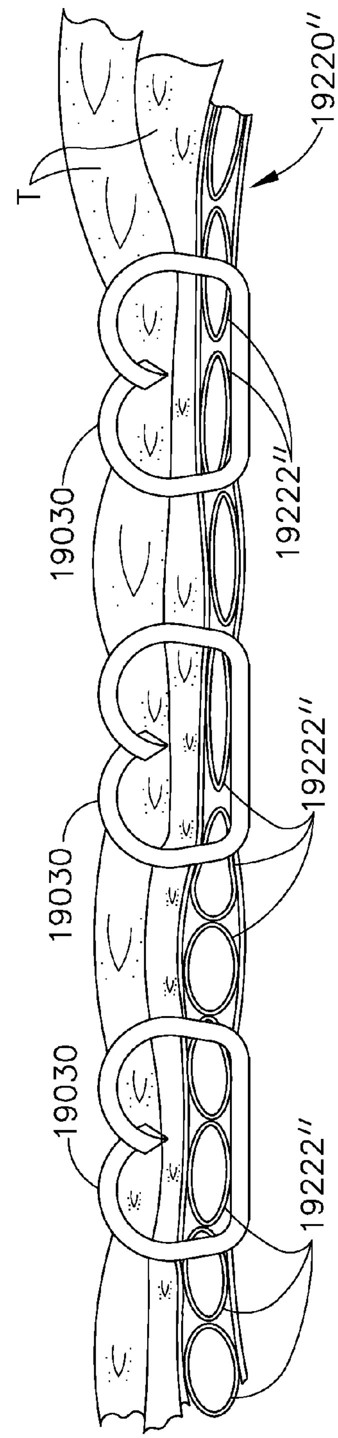


FIG. 186

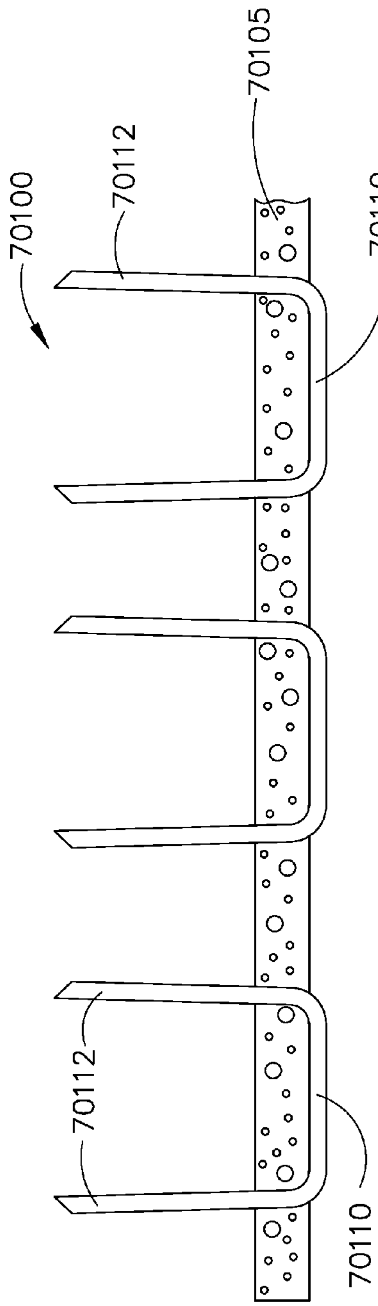


FIG. 187

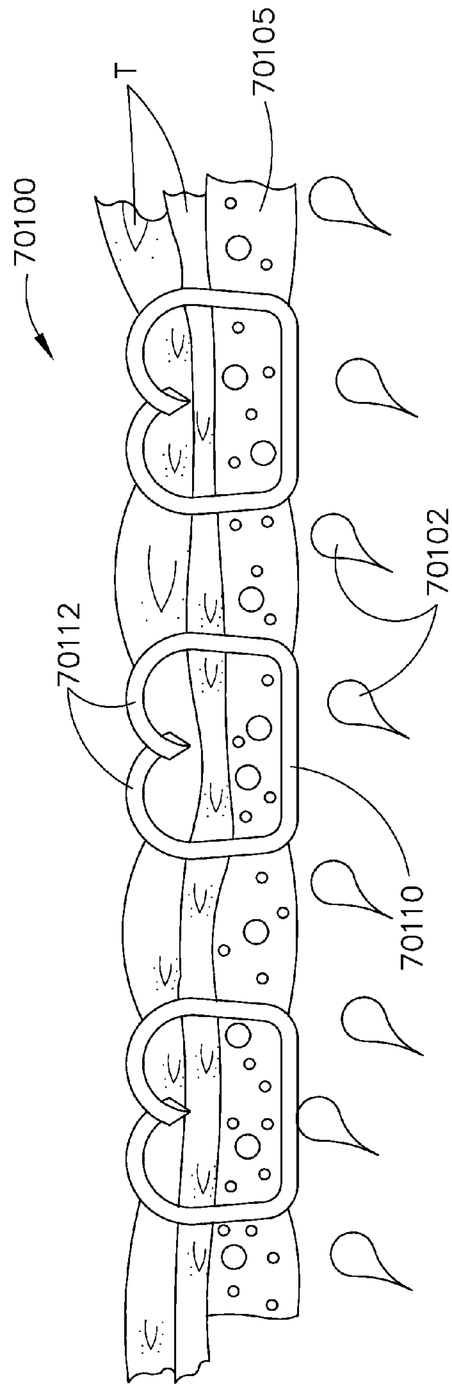


FIG. 188

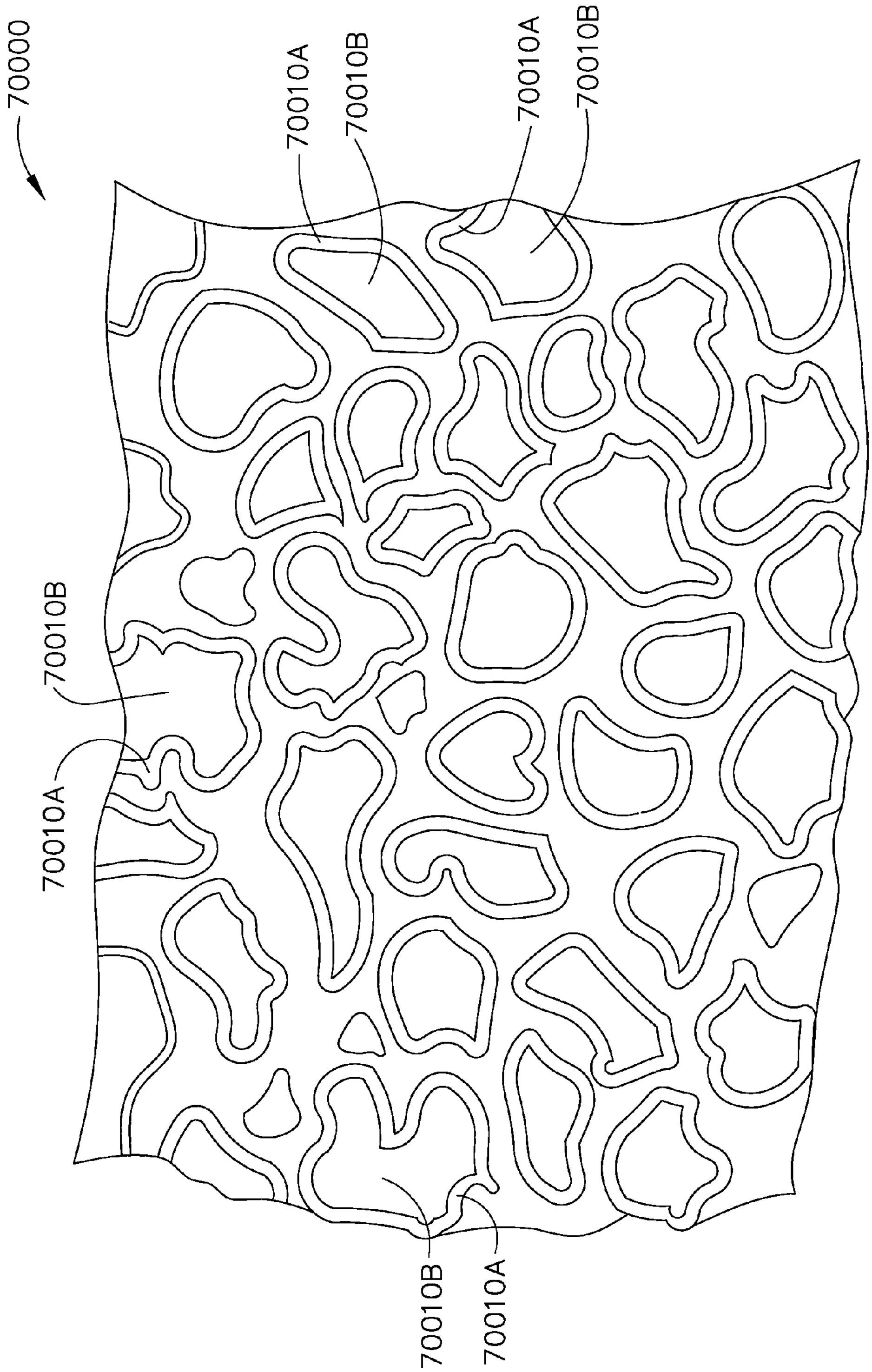

70000
70010A
70010B
70010A
70010B
70010B
70010A
70010B
70010A

FIG. 189A

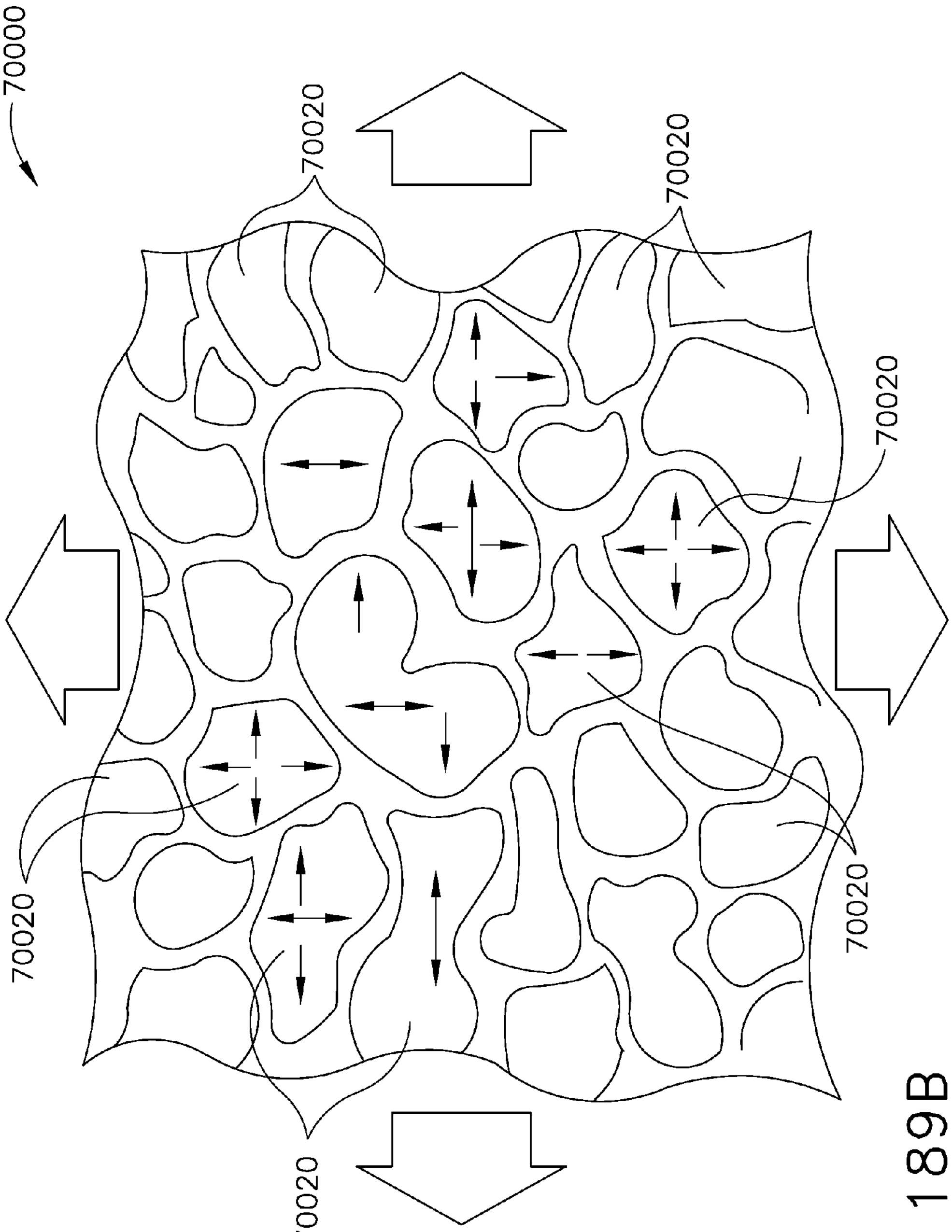


FIG. 189B

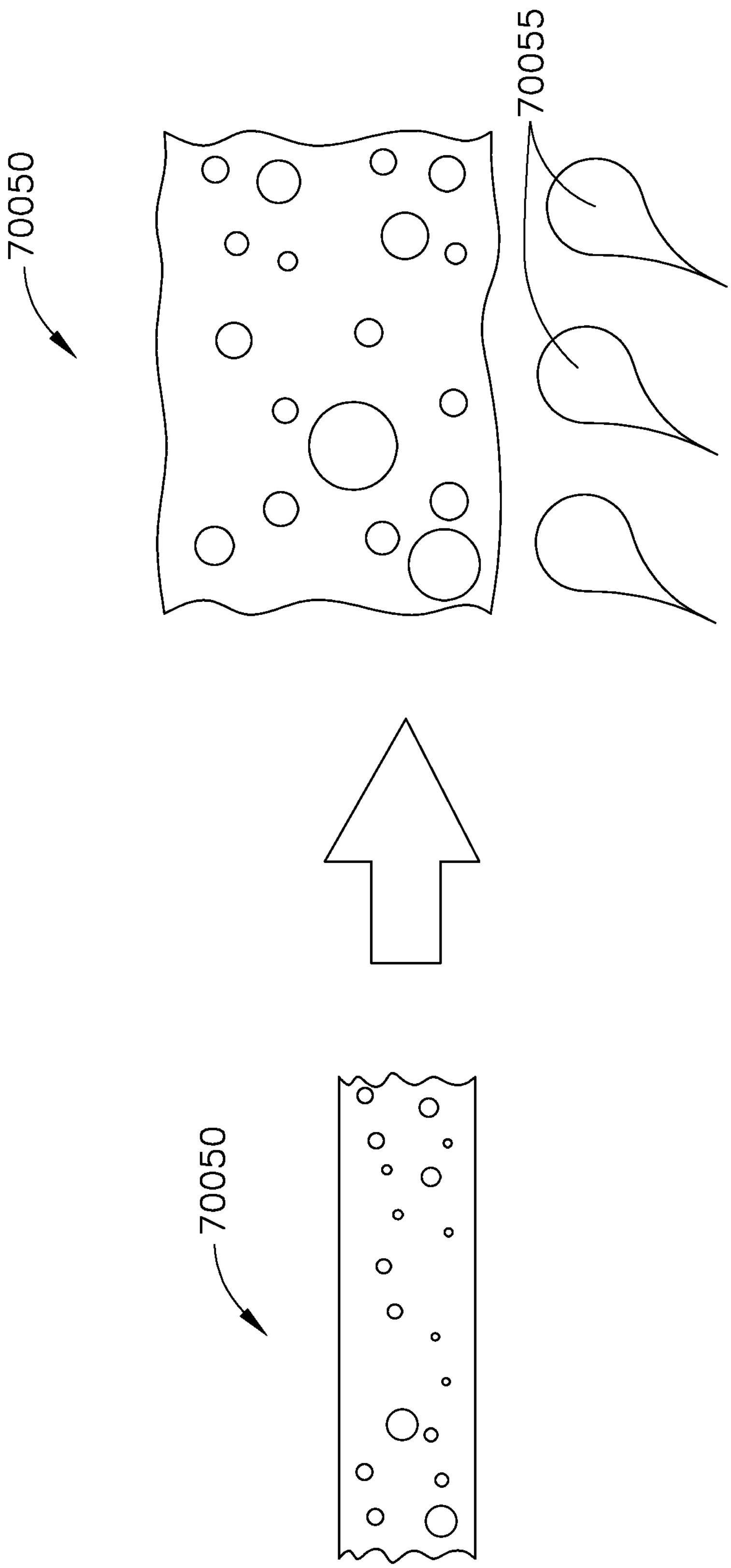


FIG. 190

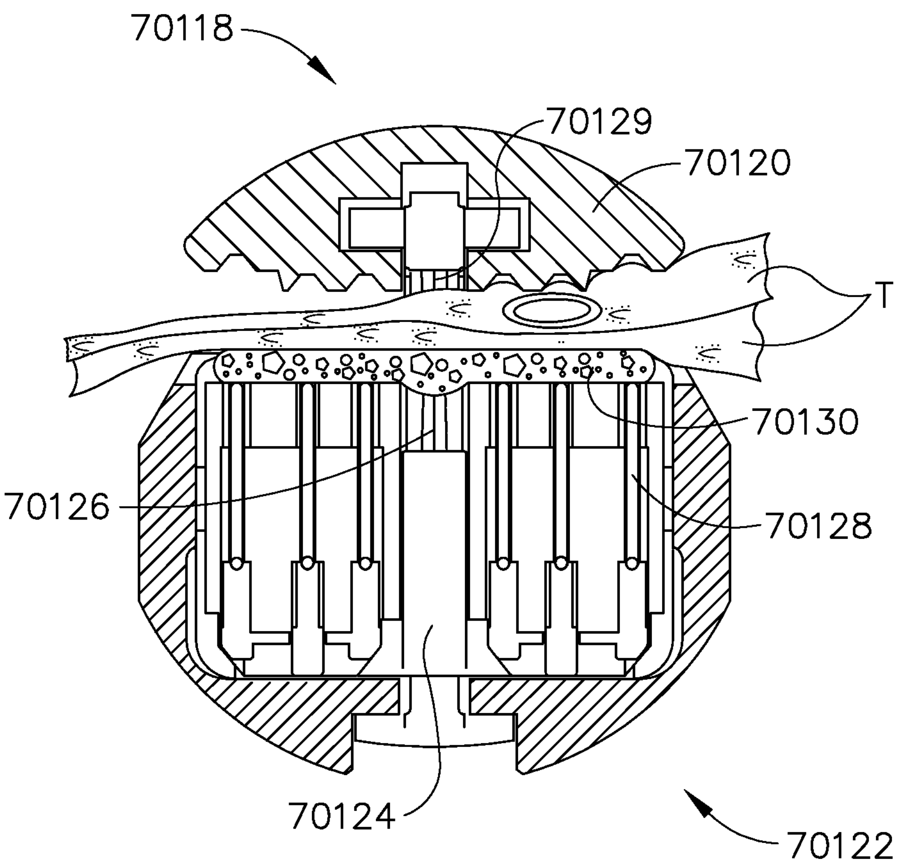


FIG. 191

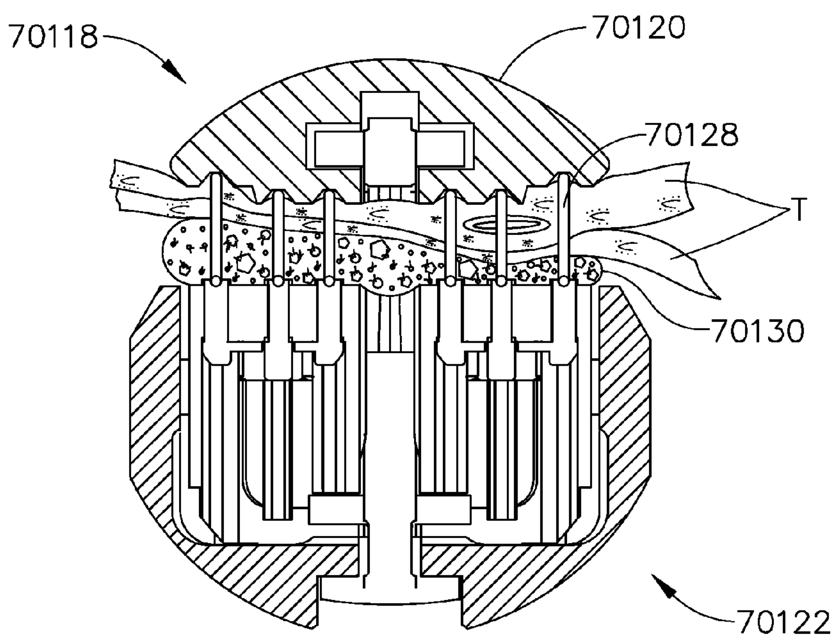


FIG. 192

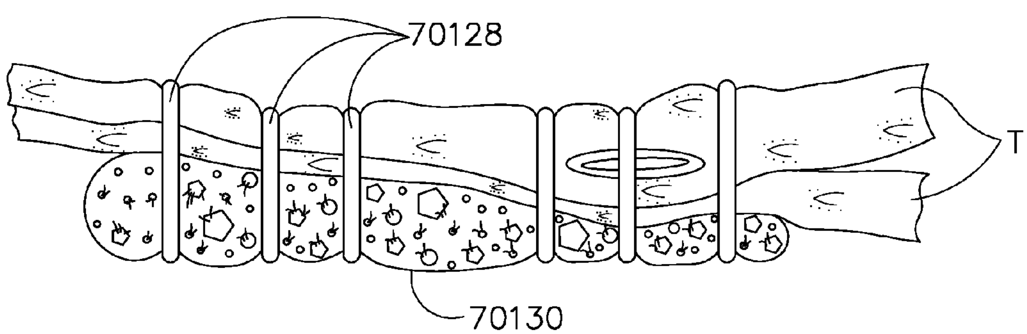


FIG. 193

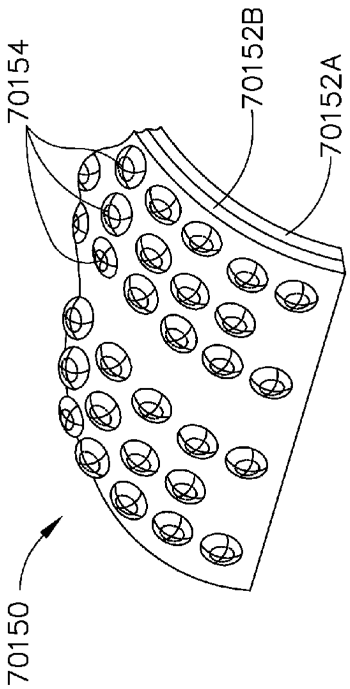


FIG. 194

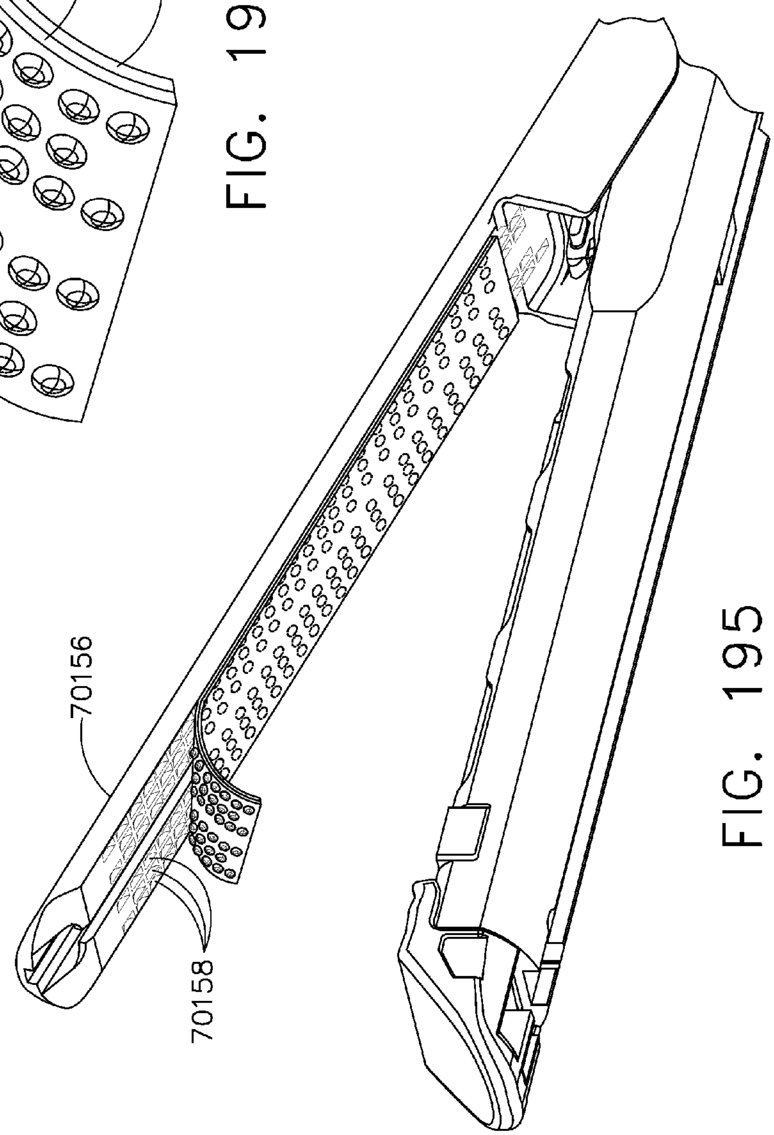


FIG. 195

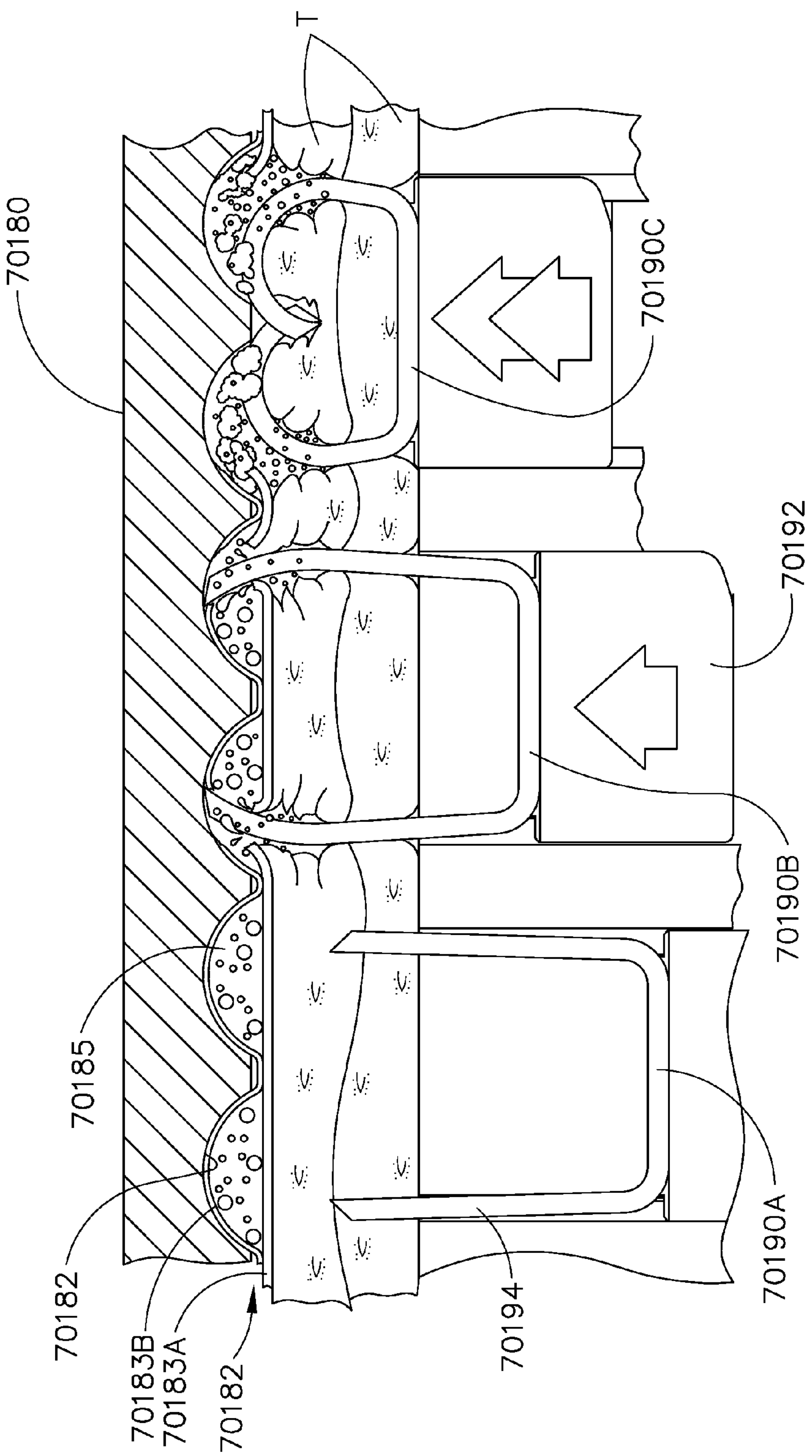

T
70180
70190C
70192
70190B
70185
70190A
70182
70183B
70183A
70182
70194

FIG. 196

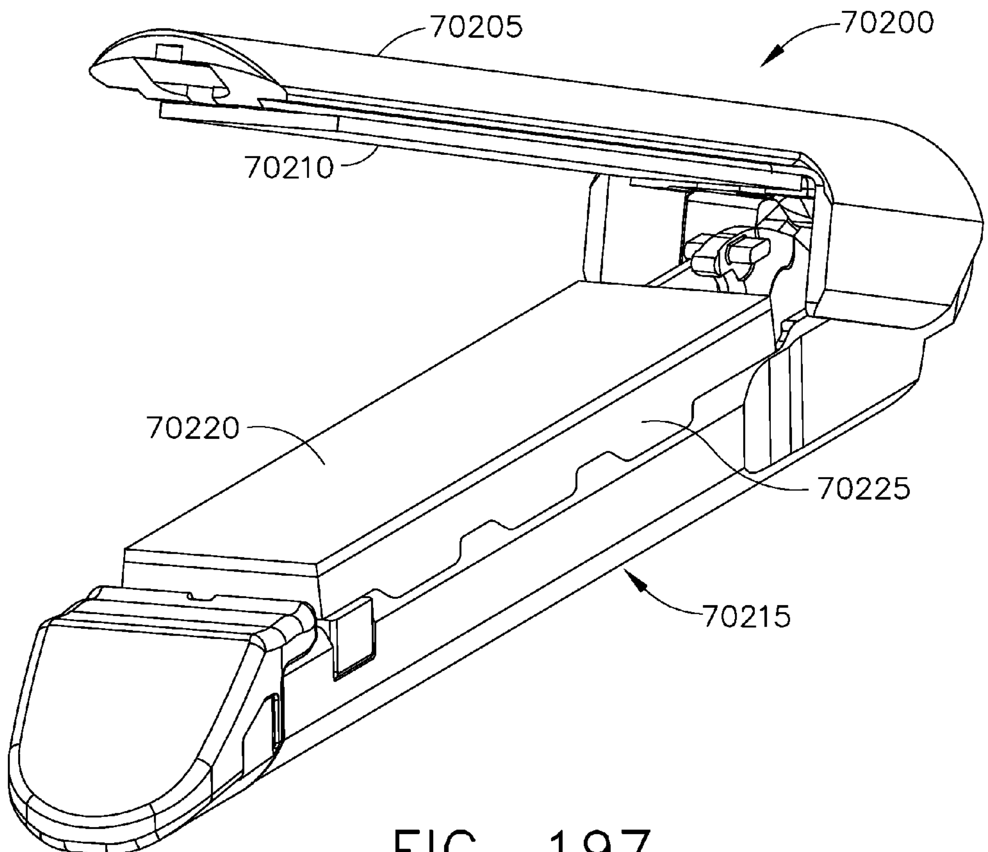


FIG. 197

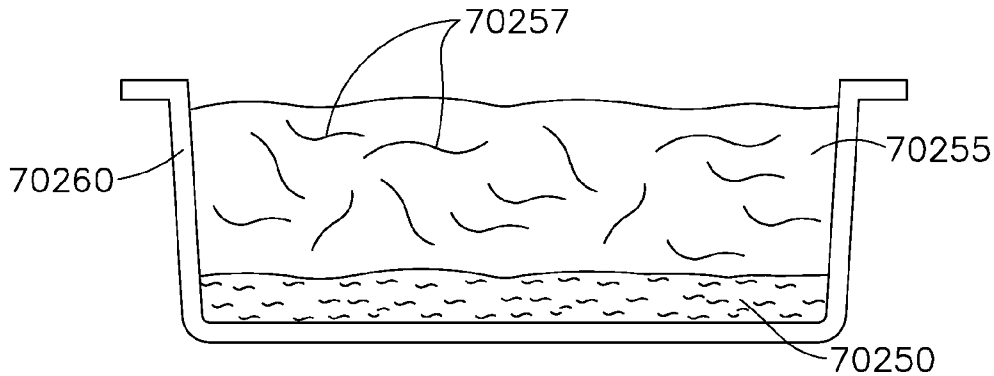


FIG. 198A

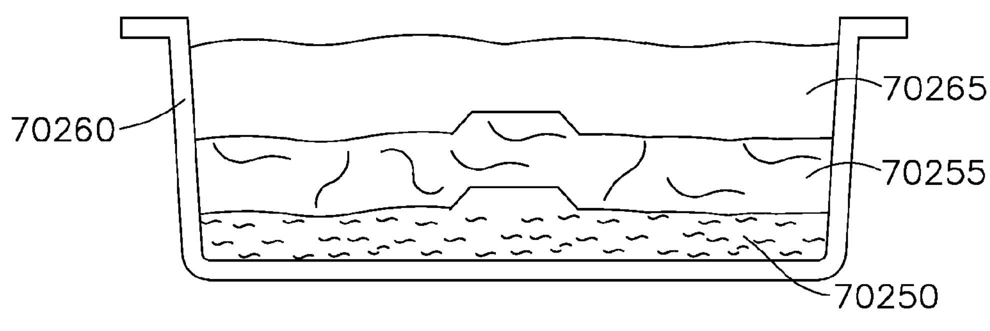


FIG. 198B

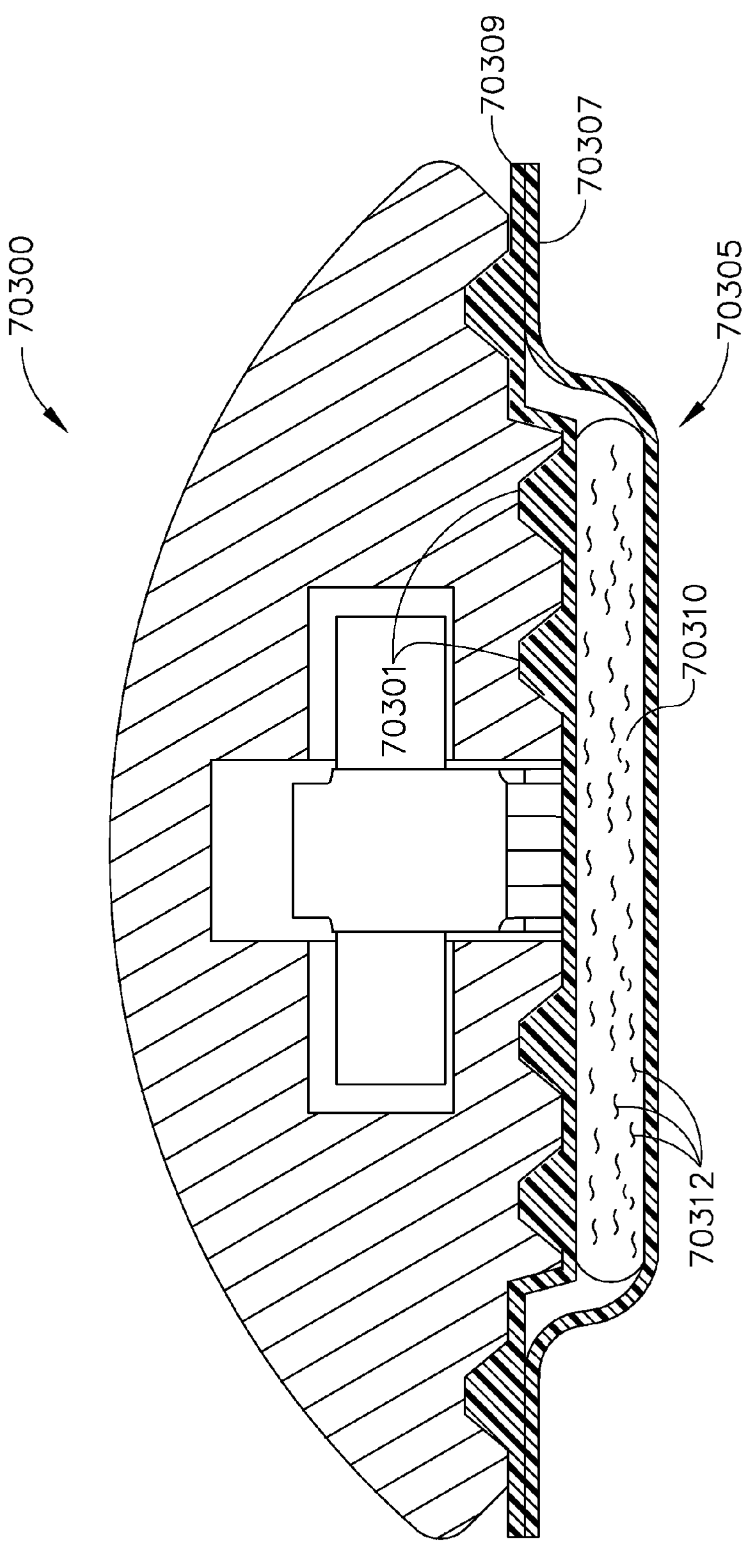


FIG. 199

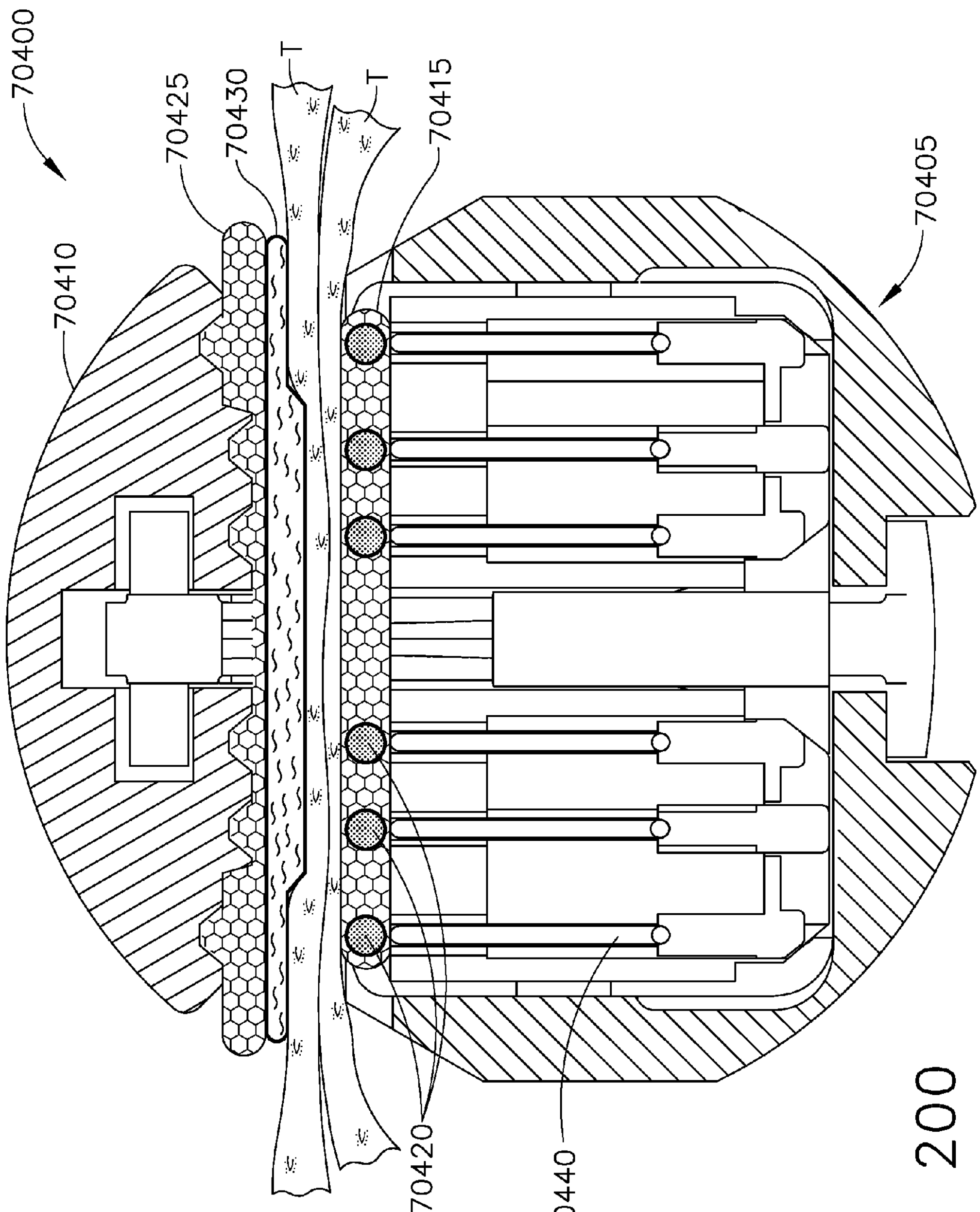


FIG. 200

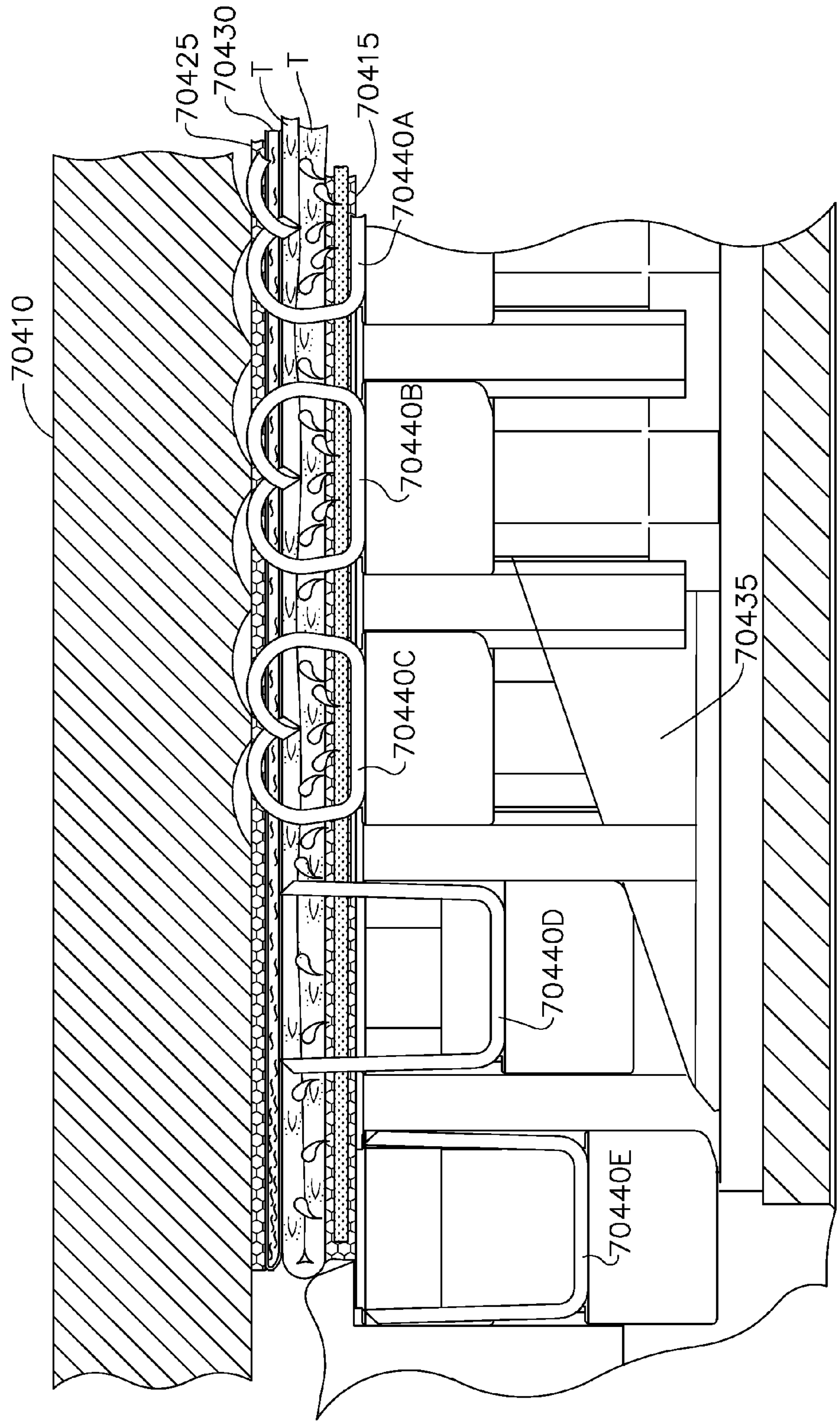

70410
70425
70430
T
T
70415
70440A
70440B
70440C
70435
70440D
70440E

FIG. 201

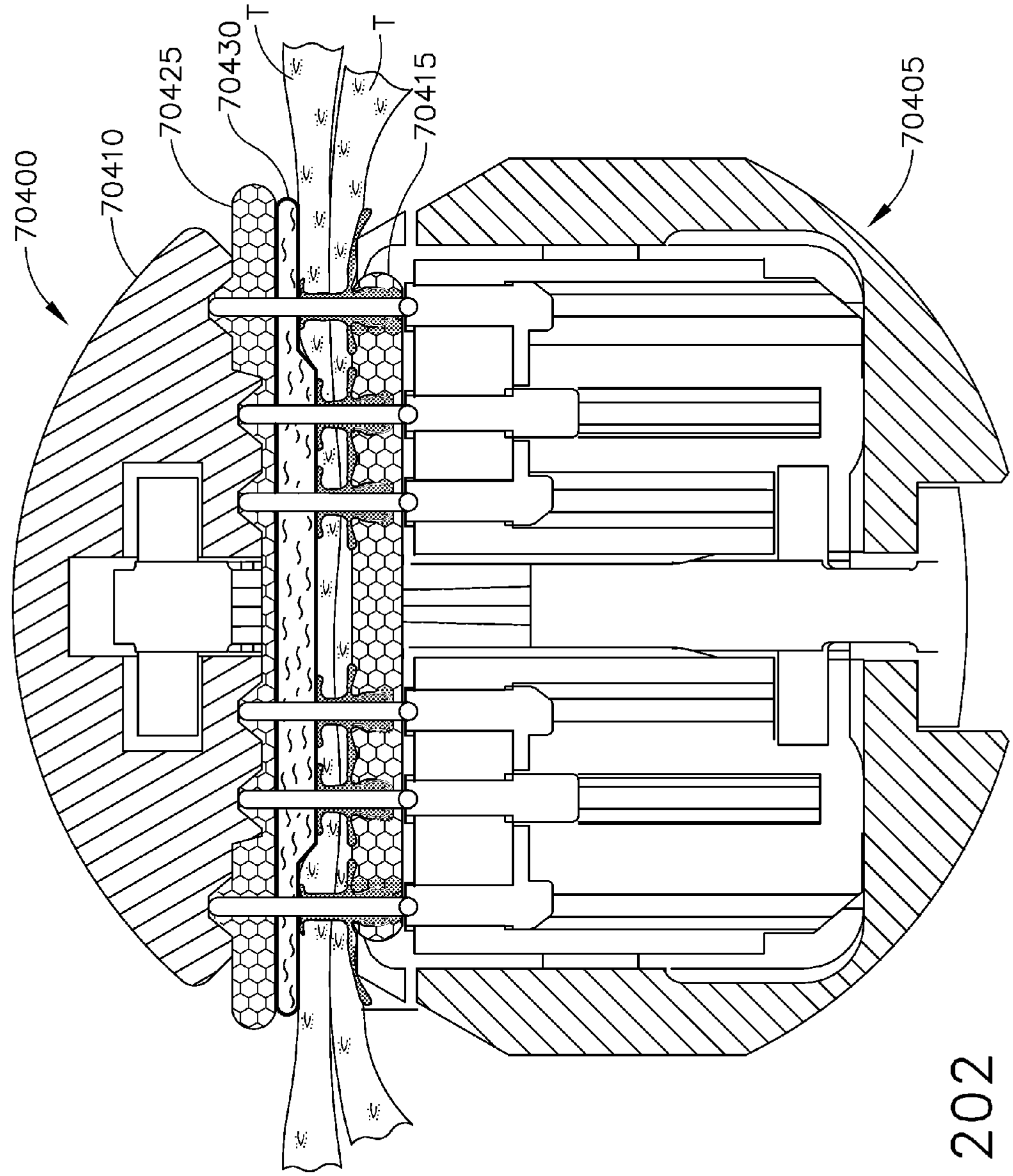


FIG. 202

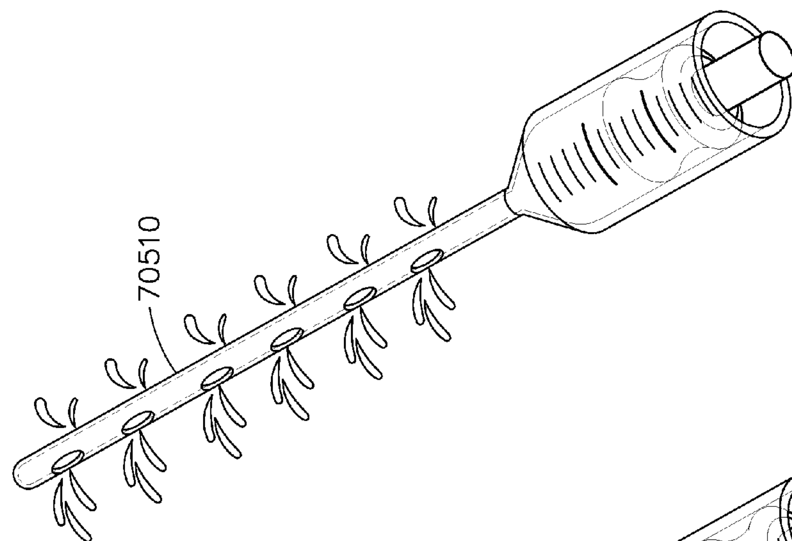


FIG. 203A

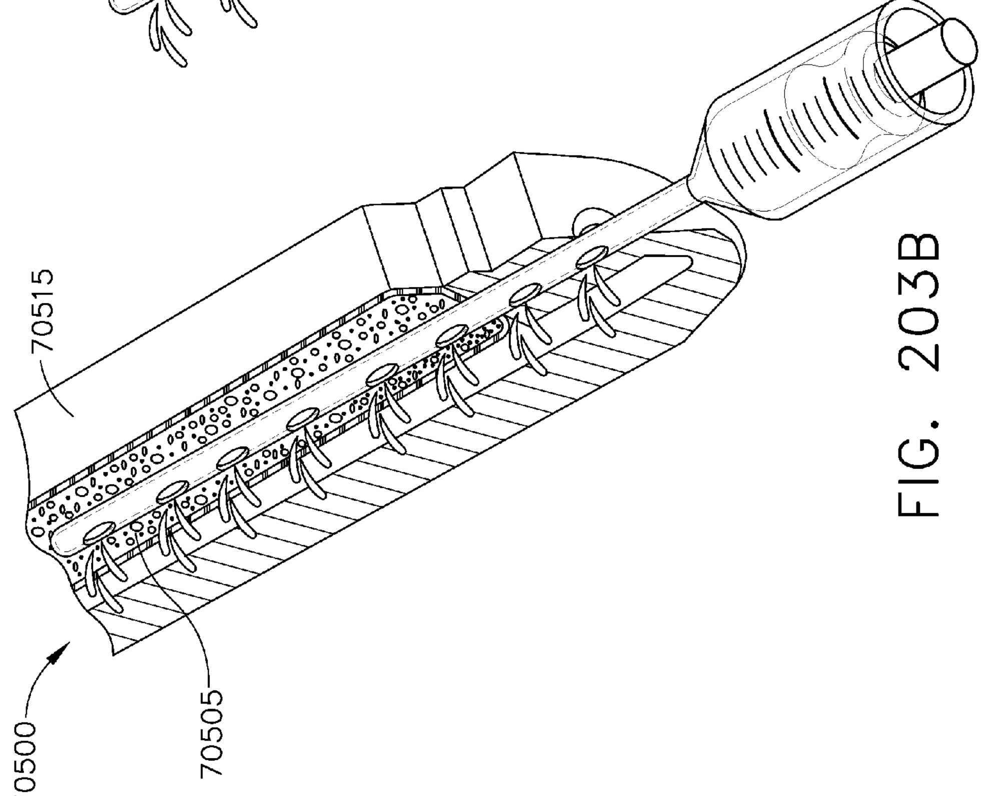


FIG. 203B

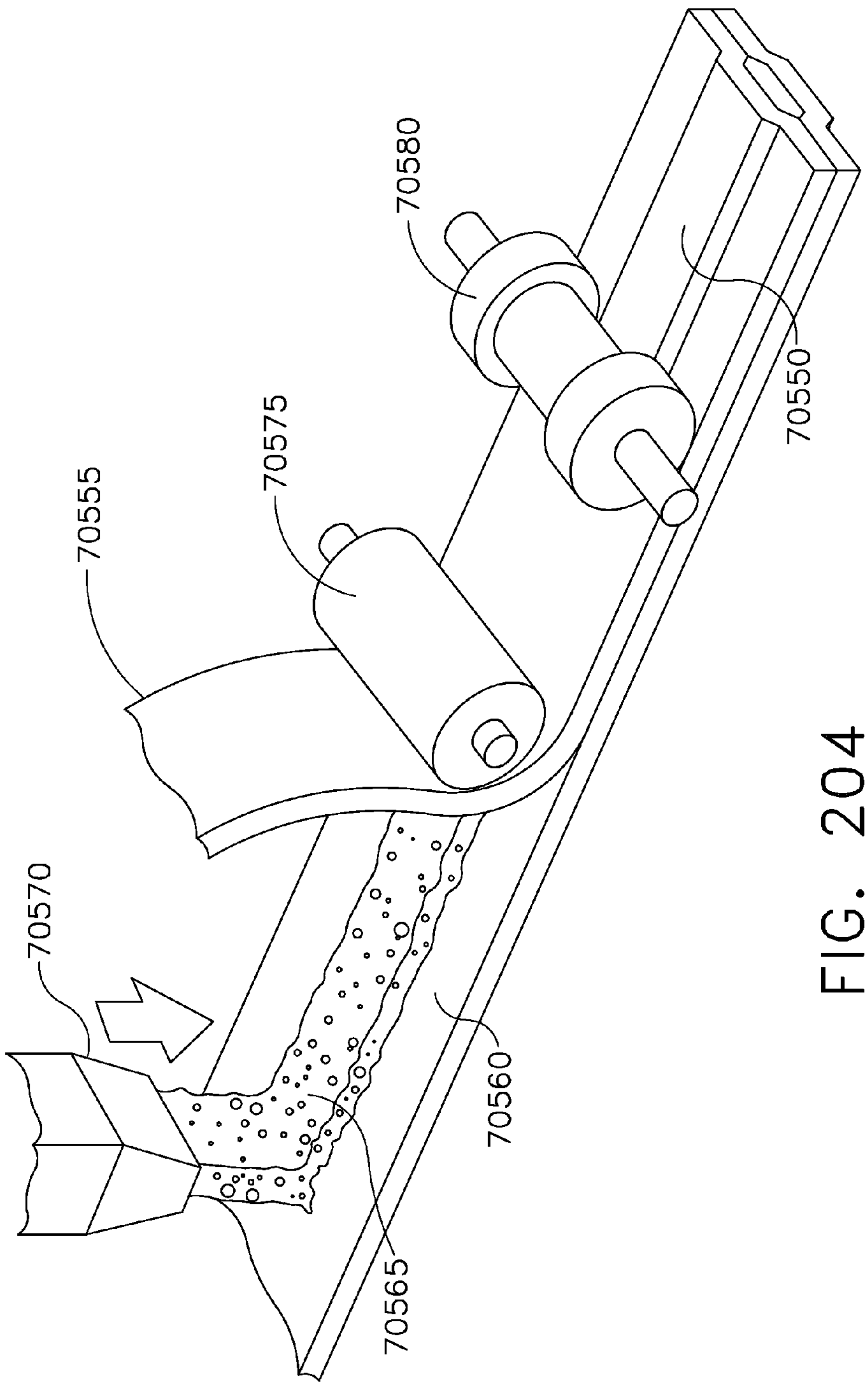


FIG. 204

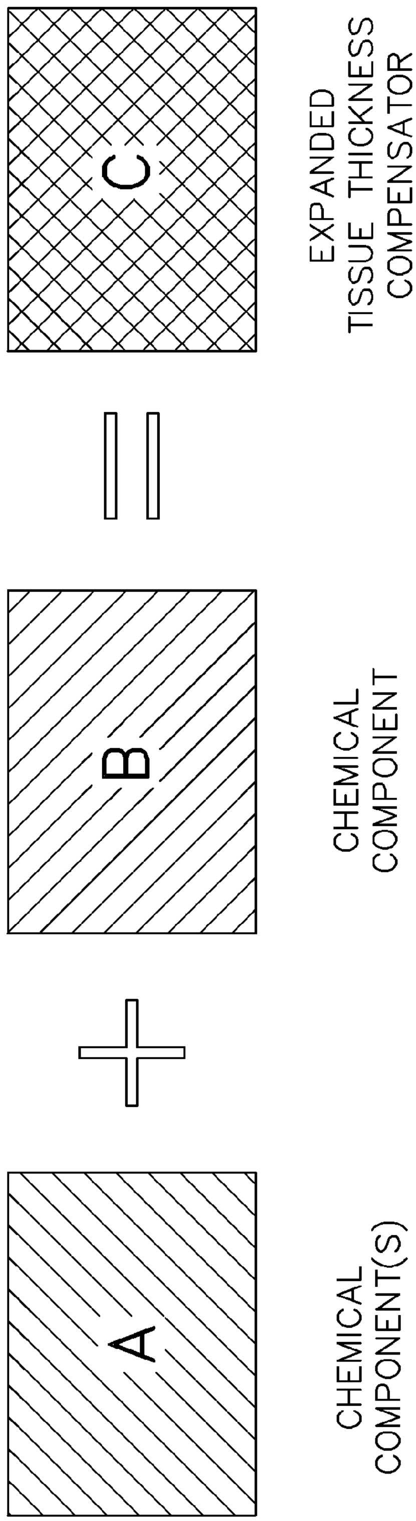

A
CHEMICAL COMPONENT(S)
B
CHEMICAL COMPONENT
C
EXPANDED TISSUE THICKNESS COMPENSATOR

FIG. 205

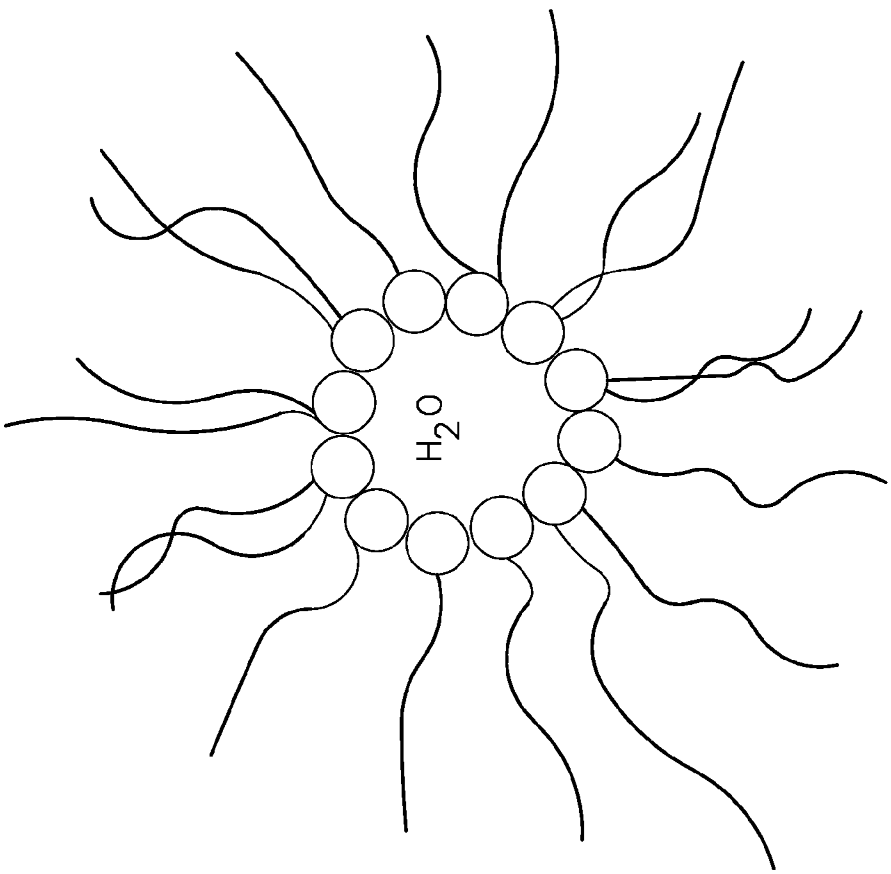


FIG. 206

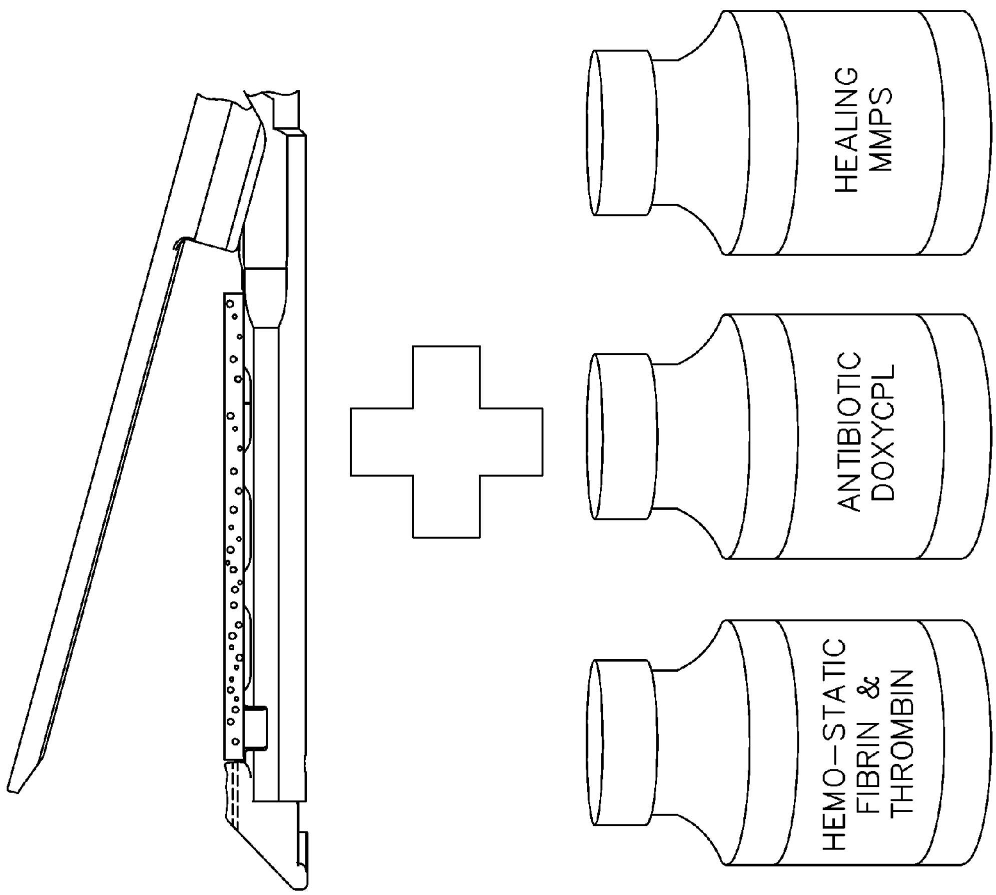

HEALING
MMPS
ANTIBIOTIC
DOXYCPL
HEMO-STATIC
FIBRIN &
THROMBIN

FIG. 207

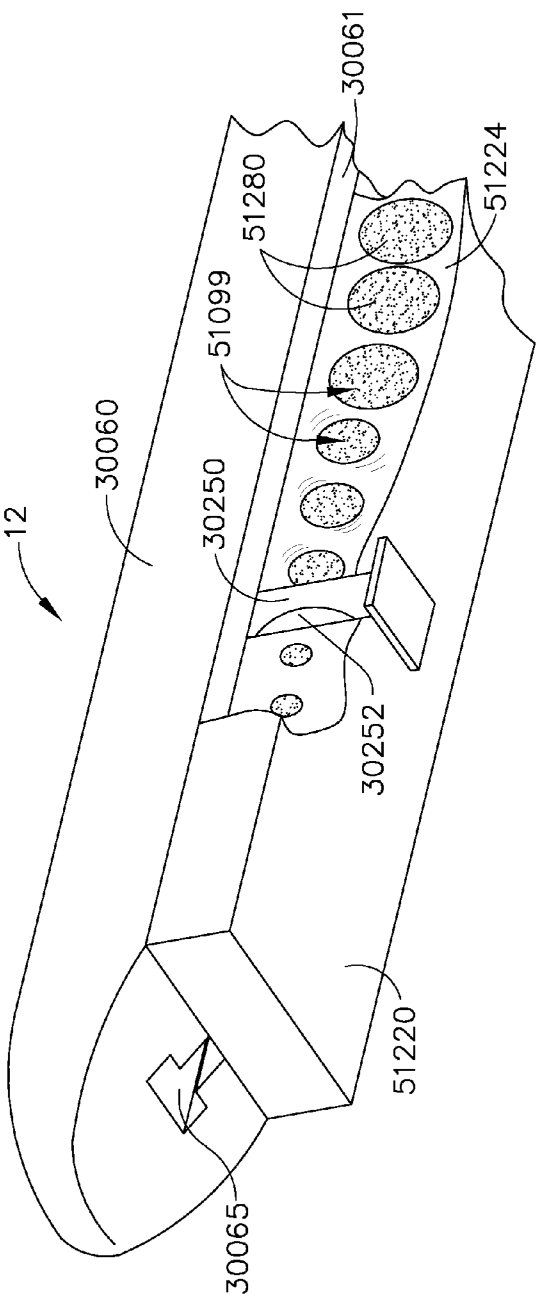


FIG. 208

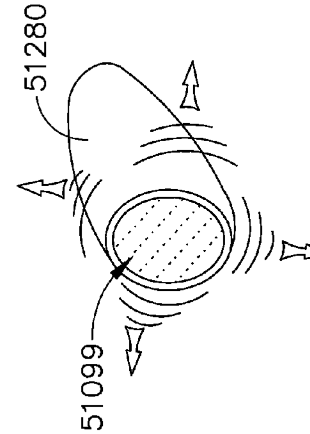


FIG. 211

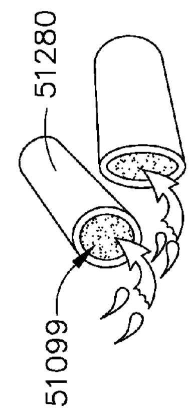


FIG. 210

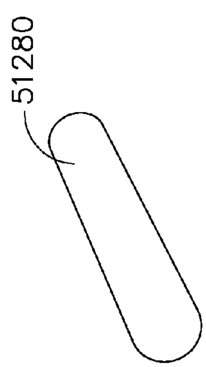


FIG. 209

TISSUE THICKNESS COMPENSATOR COMPRISING STRUCTURE TO PRODUCE A RESILIENT LOAD

CROSS-REFERENCE TO RELATED APPLICATIONS

This non-provisional patent application is a continuation-in-part application under 35 U.S.C. §120 of U.S. patent application Ser. No. 13/097,891, entitled "Tissue Thickness Compensator For A Surgical Stapler Comprising An Adjustable Anvil, filed on Apr. 29, 2011, which issued on Oct. 21, 2014 as U.S. Pat. No. 8,864,009, which is a continuation-in-part application under 35 U.S.C. §120 of U.S. patent application Ser. No. 12/894,377, entitled "Selectively Orientable Implantable Fastener Cartridge", filed on Sep. 30, 2010, which issued on Mar. 12, 2013 as U.S. Pat. No. 8,393,514, the entire disclosures of which are hereby incorporated by reference herein.

BACKGROUND

The present invention relates to surgical instruments and, in various embodiments, to surgical cutting and stapling instruments and staple cartridges therefor that are designed to cut and staple tissue.

BRIEF DESCRIPTION OF THE DRAWINGS

The features and advantages of this invention, and the manner of attaining them, will become more apparent and the invention itself will be better understood by reference to the following description of embodiments of the invention taken in conjunction with the accompanying drawings, wherein:

FIG. **1** is a cross-sectional view of a surgical instrument embodiment;

FIG. **1**A is a perspective view of one embodiment of an implantable staple cartridge;

FIGS. **1**B-**1**E illustrate portions of an end effector clamping and stapling tissue with an implantable staple cartridge;

FIG. **2** is a partial cross-sectional side view of another end effector coupled to a portion of a surgical instrument with the end effector supporting a surgical staple cartridge and with the anvil thereof in an open position;

FIG. **3** is another partial cross-sectional side view of the end effector of FIG. **2** in a closed position;

FIG. **4** is another partial cross-sectional side view of the end effector of FIGS. **2** and **3** as the knife bar is starting to advance through the end effector;

FIG. **5** is another partial cross-sectional side view of the end effector of FIGS. **2**-**4** with the knife bar partially advanced therethrough;

FIGS. **6**A-**6**D diagram the deformation of a surgical staple positioned within a collapsible staple cartridge body in accordance with at least one embodiment;

FIG. **7**A is a diagram illustrating a staple positioned in a crushable staple cartridge body;

FIG. **7**B is a diagram illustrating the crushable staple cartridge body of FIG. **7**A being crushed by an anvil;

FIG. **7**C is a diagram illustrating the crushable staple cartridge body of FIG. **7**A being further crushed by the anvil;

FIG. **7**D is a diagram illustrating the staple of FIG. **7**A in a fully formed configuration and the crushable staple cartridge of FIG. **7**A in a fully crushed condition;

FIG. **8** is a top view of a staple cartridge in accordance with at least one embodiment comprising staples embedded in a collapsible staple cartridge body;

FIG. **9** is an elevational view of the staple cartridge of FIG. **8**;

FIG. **10** is an exploded perspective view of an alternative embodiment of a compressible staple cartridge comprising staples therein and a system for driving the staples against an anvil;

FIG. **10**A is a partial cut-away view of an alternative embodiment of the staple cartridge of FIG. **10**;

FIG. **11** is a cross-sectional view of the staple cartridge of FIG. **10**;

FIG. **12** is an elevational view of a sled configured to traverse the staple cartridge of FIG. **10** and move the staples to toward the anvil;

FIG. **13** is a diagram of a staple driver which can be lifted toward the anvil by the sled of FIG. **12**;

FIG. **14** is a perspective view of a staple cartridge comprising a rigid support portion and a compressible tissue thickness compensator for use with a surgical stapling instrument in accordance with at least one embodiment of the invention;

FIG. **15** is a partially exploded view of the staple cartridge of FIG. **14**;

FIG. **16** is a fully exploded view of the staple cartridge of FIG. **14**;

FIG. **17** is another exploded view of the staple cartridge of FIG. **14** without a warp covering the tissue thickness compensator;

FIG. **18** is a perspective view of a cartridge body, or support portion, of the staple cartridge of FIG. **14**;

FIG. **19** is a top perspective view of a sled movable within the staple cartridge of FIG. **14** to deploy staples from the staple cartridge;

FIG. **20** is a bottom perspective view of the sled of FIG. **19**;

FIG. **21** is an elevational view of the sled of FIG. **19**;

FIG. **22** is a top perspective view of a driver configured to support one or more staples and to be lifted upwardly by the sled of FIG. **19** to eject the staples from the staple cartridge;

FIG. **23** is a bottom perspective view of the driver of FIG. **22**;

FIG. **24** is a wrap configured to at least partially surround a compressible tissue thickness compensator of a staple cartridge;

FIG. **25** is a partial cut away view of a staple cartridge comprising a rigid support portion and a compressible tissue thickness compensator illustrated with staples being moved from an unfired position to a fired position during a first sequence;

FIG. **26** is an elevational view of the staple cartridge of FIG. **25**;

FIG. **27** is a detail elevational view of the staple cartridge of FIG. **25**;

FIG. **28** is a cross-sectional end view of the staple cartridge of FIG. **25**;

FIG. **29** is a bottom view of the staple cartridge of FIG. **25**;

FIG. **30** is a detail bottom view of the staple cartridge of FIG. **25**;

FIG. **31** is a longitudinal cross-sectional view of an anvil in a closed position and a staple cartridge comprising a rigid support portion and a compressible tissue thickness compensator illustrated with staples being moved from an unfired position to a fired position during a first sequence;

FIG. **32** is another cross-sectional view of the anvil and the staple cartridge of FIG. **31** illustrating the anvil in an open position after the firing sequence has been completed;

FIG. **33** is a partial detail view of the staple cartridge of FIG. **31** illustrating the staples in an unfired position;

FIG. **34** is a cross-sectional elevational view of a staple cartridge comprising a rigid support portion and a compressible tissue thickness compensator illustrating the staples in an unfired position;

FIG. **35** is a detail view of the staple cartridge of FIG. **34**;

FIG. **36** is an elevational view of an anvil in an open position and a staple cartridge comprising a rigid support portion and a compressible tissue thickness compensator illustrating the staples in an unfired position;

FIG. **37** is an elevational view of an anvil in a closed position and a staple cartridge comprising a rigid support portion and a compressible tissue thickness compensator illustrating the staples in an unfired position and tissue captured between the anvil and the tissue thickness compensator;

FIG. **38** is a detail view of the anvil and staple cartridge of FIG. **37**;

FIG. **39** is an elevational view of an anvil in a closed position and a staple cartridge comprising a rigid support portion and a compressible tissue thickness compensator illustrating the staples in an unfired position illustrating thicker tissue positioned between the anvil and the staple cartridge;

FIG. **40** is a detail view of the anvil and staple cartridge of FIG. **39**;

FIG. **41** is an elevational view of the anvil and staple cartridge of FIG. **39** illustrating tissue having different thicknesses positioned between the anvil and the staple cartridge;

FIG. **42** is a detail view of the anvil and staple cartridge of FIG. **39** as illustrated in FIG. **41**;

FIG. **43** is a diagram illustrating a tissue thickness compensator which is compensating for different tissue thickness captured within different staples;

FIG. **44** is a diagram illustrating a tissue thickness compensator applying a compressive pressure to one or more vessels that have been transected by a staple line;

FIG. **45** is a diagram illustrating a circumstance wherein one or more staples have been improperly formed;

FIG. **46** is a diagram illustrating a tissue thickness compensator which could compensate for improperly formed staples;

FIG. **47** is a diagram illustrating a tissue thickness compensator positioned in a region of tissue in which multiple staples lines have intersected;

FIG. **48** is a diagram illustrating tissue captured within a staple;

FIG. **49** is a diagram illustrating tissue and a tissue thickness compensator captured within a staple;

FIG. **50** is a diagram illustrating tissue captured within a staple;

FIG. **51** is a diagram illustrating thick tissue and a tissue thickness compensator captured within a staple;

FIG. **52** is a diagram illustrating thin tissue and a tissue thickness compensator captured within a staple;

FIG. **53** is a diagram illustrating tissue having an intermediate thickness and a tissue thickness compensator captured within a staple;

FIG. **54** is a diagram illustrating tissue having another intermediate thickness and a tissue thickness compensator captured within a staple;

FIG. **55** is a diagram illustrating thick tissue and a tissue thickness compensator captured within a staple;

FIG. **56** is a partial cross-sectional view of an end effector of a surgical stapling instrument illustrating a firing bar and staple-firing sled in a retracted, unfired position;

FIG. **57** is another partial cross-sectional view of the end effector of FIG. **56** illustrating the firing bar and the staple-firing sled in a partially advanced position;

FIG. **58** is a cross-sectional view of the end effector of FIG. **56** illustrating the firing bar in a fully advanced, or fired, position;

FIG. **59** is a cross-sectional view of the end effector of FIG. **56** illustrating the firing bar in a retracted position after being fired and the staple-firing sled left in its fully fired position;

FIG. **60** is a detail view of the firing bar in the retracted position of FIG. **59**;

FIG. **61** is a perspective view of a tissue thickness compensator in an end effector of a surgical instrument according to at least one embodiment;

FIG. **62** is a detail view of nonwoven material of the tissue thickness compensator of FIG. **61**;

FIG. **63** is an elevational view depicting the tissue thickness compensator of FIG. **61** implanted against tissue and released from the end effector;

FIG. **64** is a detail view of nonwoven material of a tissue thickness compensator according to at least one embodiment;

FIG. **65** is a schematic depicting clusters of randomly oriented crimped fibers according to at least one embodiment;

FIG. **66** is a schematic depicting a cluster of randomly oriented crimped fibers according to at least one embodiment;

FIG. **67** is a schematic depicting an arrangement of crimped fibers according to at least one embodiment;

FIG. **68** is a schematic depicting an arrangement of crimped fibers according to at least one embodiment;

FIG. **69** is a schematic depicting an arrangement of crimped fibers according to at least one embodiment;

FIG. **70** is a plan cross-sectional view of coiled fibers in a tissue thickness compensator according to at least one embodiment;

FIG. **70**A is a plan cross-sectional view of the coiled fibers of FIG. **70**;

FIG. **70**B is a cross-sectional detail view of the tissue thickness compensator of FIG. **70**;

FIG. **71** is a perspective view of a tissue thickness compensator in an end effector of a surgical instrument according to at least one embodiment;

FIG. **72** is a diagram depicting deformation of the tissue thickness compensator of FIG. **71**;

FIG. **73** is a schematic of woven suture for a tissue thickness compensator depicting the woven suture in a loaded configuration according to at least one embodiment;

FIG. **74** is a schematic of the woven suture of FIG. **73** depicting the woven suture in a released configuration;

FIG. **75** is a plan view of a tissue thickness compensator having the woven suture of FIG. **73** in an end effector of a surgical instrument;

FIG. **76** is a perspective view of a tissue thickness compensator in an end effector of a surgical instrument according to at least one embodiment;

FIG. **77** is a partial plan view of the tissue thickness compensator of FIG. **76**;

FIG. **78** is an exploded view of the fastener cartridge assembly of the end effector and tissue thickness compensator of FIG. **61**;

FIG. **79** is a partial cross-sectional view of the fastener cartridge assembly of FIG. **78** depicting unfired, partially fired, and fired fasteners;

FIG. **80** is an elevational view of the fastener cartridge assembly of FIG. **78** depicting a driver firing fasteners from staple cavities of the fastener cartridge assembly into the tissue thickness compensator;

FIG. **81** is a detail view of the fastener cartridge assembly of FIG. **80**;

FIG. **82** is an elevational view of the tissue thickness compensator of FIG. **61** and tissue captured within fired fasteners;

FIG. **83** is an elevational view of the tissue thickness compensator of FIG. **61** and tissue captured within fired fasteners;

FIG. **84** is a perspective view of a tissue thickness compensator in an end effector of a surgical instrument according to at least one embodiment;

FIG. **85** is a diagram depicting deformation of a deformable tube of the tissue thickness compensator of FIG. **84**;

FIG. **86** is a detail view of the deformable tube of the tissue thickness compensator of FIG. **84**;

FIG. **87** is a diagram depicting deformation of a deformable tube of a tissue thickness compensator according to at least one embodiment;

FIG. **88** is an elevational view of a tissue thickness compensator comprising a tubular element implanted against tissue according to at least one embodiment;

FIG. **89** is an elevational view of a tissue thickness compensator comprising tubular elements implanted against tissue according to at least one embodiment;

FIG. **90** is a partial perspective view of a deformable tube comprising a tubular lattice according to at least one embodiment;

FIG. **91** is an elevational view of a tubular strand of the deformable tube of FIG. **90**.

FIG. **92** is an elevational view of the deformable tube of FIG. **90**;

FIG. **93** is an elevational view of multiple tubular strands for the deformable tube of FIG. **90** according to various embodiments;

FIG. **94** is an elevational view of the tubular lattice of FIG. **90** implanted against tissue;

FIG. **95** is a partial perspective view of a deformable tube according to at least one embodiment;

FIG. **96** is a partial perspective view of a deformable tube according to at least one embodiment;

FIG. **97** is a partial perspective view of a deformable tube according to at least one embodiment;

FIG. **98** is an elevational view of the deformable tube of FIG. **97**;

FIG. **99** is a partial perspective view of a deformable tube according to at least one embodiment;

FIG. **100** is a partial perspective view of a deformable tube according to at least one embodiment;

FIG. **101** is a partial perspective view of a deformable tube according to at least one embodiment;

FIG. **102** is a perspective view of a tissue thickness compensator positioned in an end effector of a surgical instrument according to at least one embodiment;

FIG. **103** is an elevational view of a tubular element of the tissue thickness compensator of FIG. **102**;

FIG. **104** is an elevational cross-sectional view of the tissue thickness compensator and the end effector of FIG. **102** depicting the end effector in an unclamped configuration;

FIG. **105** is an elevational cross-sectional view of the tissue thickness compensator and the end effector of FIG. **102** depicting the end effector in a clamped and fired configuration;

FIG. **106** is an elevational cross-sectional view of a tissue thickness compensator positioned in an end effector of a surgical instrument according to at least one embodiment;

FIG. **107** is an elevational cross-sectional view of the tissue thickness compensator and the end effector of FIG. **106** depicting the end effector in a clamped and fired configuration;

FIG. **108** is an elevational cross-sectional view of a tissue thickness compensator in the end effector of a surgical instrument according to at least one embodiment;

FIG. **109** is a cross-sectional elevational view of a tissue thickness compensator positioned in an end effector of a surgical instrument according to at least one embodiment;

FIG. **110** is a cross-sectional elevational view of the tissue thickness compensator and the end effector of FIG. **109** depicting the end effector in a clamped and fired configuration;

FIG. **111** is a perspective view of a tissue thickness compensator positioned in an end effector of a surgical instrument according to at least one embodiment;

FIG. **112** is an elevational cross-sectional view of a tissue thickness compensator positioned in an end effector of a surgical instrument according to at least one embodiment;

FIG. **113** is an elevational cross-sectional view of a tissue thickness compensator positioned in an end effector of a surgical instrument according to at least one embodiment;

FIG. **114** is an elevational cross-sectional view of a tissue thickness compensator positioned in an end effector of a surgical instrument according to at least one embodiment;

FIG. **115** is an elevational cross-sectional view of a tissue thickness compensator positioned in an end effector of a surgical instrument according to at least one embodiment;

FIG. **116** is a partial plan view of a tissue thickness compensator positioned in an end effector of a surgical instrument according to at least one embodiment;

FIG. **117** is a partial plan view of a tissue thickness compensator positioned in an end effector of a surgical instrument according to at least one embodiment;

FIG. **118** is a partial elevational cross-sectional view of the tissue thickness compensator and the end effector of FIG. **116** depicting the end effector in an unclamped configuration;

FIG. **119** is a partial elevational cross-sectional view of the tissue thickness compensator and the end effector of FIG. **116** depicting the end effector in a clamped configuration;

FIG. **120** is a perspective view of a tissue thickness compensator in an end effector of a surgical instrument according to at least one embodiment;

FIG. **121** is an elevational view of the tissue thickness compensator and the end effector of FIG. **120**;

FIG. **122** is a perspective view of the tissue thickness compensator and the end effector of FIG. **120** depicting the anvil of the end effector moving towards a clamped configuration;

FIG. **123** is an elevational view of the tissue thickness compensator and the end effector of FIG. **120** depicting the end effector in a clamped configuration;

FIG. **124** is an elevational cross-sectional view of tubular elements of the tissue thickness compensator of FIG. **120** in an undeformed configuration;

FIG. **125** is an elevational cross-sectional view of tubular elements of the tissue thickness compensator of FIG. **120** in a deformed configuration;

FIG. **126** is a perspective view of a tissue thickness compensator in an end effector of a surgical instrument according to at least one embodiment;

FIG. **127** is an elevational cross-sectional view of the tissue thickness compensator and the end effector of FIG. **126** depicting the end effector in a clamped configuration;

FIG. **128** is an elevational cross-sectional view of the tissue thickness compensator and the end effector of FIG. **126** depicting the end effector in a fired and partially unclamped configuration;

FIG. **129** is a perspective view of a tissue thickness compensator positioned in an end effector of a surgical instrument according to at least one embodiment;

FIG. **130** is an elevational cross-sectional view of a tissue thickness compensator secured to an anvil of an end effector of a surgical instrument according to at least one embodiment;

FIG. **131** is an elevational cross-sectional view of the tissue thickness compensator and the end effector of FIG. **130** depicting the end effector in a clamped configuration;

FIG. **132** is an elevational cross-sectional view of the tissue thickness compensator and the end effector of FIG. **130** depicting the end effector in a fired and partially unclamped configuration;

FIG. **133** is a detail view of the tissue thickness compensator and the end effector of FIG. **132**;

FIG. **134** is an elevational cross-sectional view of a tissue thickness compensator clamped in an end effector of a surgical instrument depicting deployment of staples by a staple-firing sled according to at least one embodiment;

FIG. **135** is an elevational cross-sectional view of the tissue thickness compensator and the end effector of FIG. **134** depicting the end effector in a clamped configuration;

FIG. **136** is an elevational cross-sectional view of the tissue thickness compensator and the end effector of FIG. **134** depicting the end effector in a fired configuration;

FIG. **137** is a perspective view of a tissue thickness compensator in an end effector of a surgical instrument according to at least one embodiment;

FIG. **138** is a perspective view of a tubular element of the tissue thickness compensator of FIG. **137**;

FIG. **139** is a perspective view of the tubular element of FIG. **138** severed between a first and second end;

FIG. **140** is a perspective view of the tissue thickness compensator of FIG. **137** depicting a cutting element severing the tissue thickness compensator and staples engaging the tissue thickness compensator;

FIG. **141** is perspective view of a frame configured to make the tissue thickness compensator of FIG. **137** according to at least one embodiment;

FIG. **142** is an elevational cross-sectional view of the frame of FIG. **141** depicting the tissue thickness compensator of FIG. **137** curing in the frame;

FIG. **143** is an elevational cross-sectional view of the tissue thickness compensator removed from the frame of FIG. **142** and prepared for trimming by at least one cutting instrument;

FIG. **144** is an elevational cross-sectional view of the tissue thickness compensator of FIG. **143** after at least one cutting instrument has trimmed the tissue thickness compensator;

FIG. **145** is an elevational cross-sectional view of the tissue thickness compensator formed in the frame of FIG. **142** depicting severable tubes having various cross-sectional geometries;

FIG. **146** is a perspective view of a tissue thickness compensator in an end effector of a surgical instrument according to at least one embodiment;

FIG. **147** is a detail view of the tissue thickness compensator of FIG. **146** according to at least one embodiment;

FIG. **148** is a partial perspective view of a tissue thickness compensator according to at least one embodiment;

FIG. **149** is a partial perspective view of a tissue thickness compensator according to at least one embodiment;

FIG. **150**A is an elevational cross-sectional view of the tissue thickness compensator and the end effector of FIG. **146** depicting the end effector in an unclamped configuration;

FIG. **150**B is an elevational cross-sectional view of the tissue thickness compensator and the end effector of FIG. **146** depicting the end effector in a clamped configuration;

FIG. **150**C is an elevational cross-sectional view of the tissue thickness compensator and the end effector of FIG. **146** depicting the end effector in a clamped and fired configuration;

FIG. **150**D is an elevational cross-sectional view of the tissue thickness compensator of FIG. **146** captured in fired staples;

FIG. **150**E is an elevational cross-sectional view of the tissue thickness compensator of FIG. **146** captured in fired staples depicting further expansion of the tissue thickness compensator;

FIG. **151** is a perspective cross-sectional view of a tissue thickness compensator in an end effector of a surgical instrument according to at least one embodiment;

FIG. **152** is a partial elevational view of the tissue thickness compensator of FIG. **151** captured in a fired staple;

FIG. **153** is an elevational view of a deformable tube of the tissue thickness compensator of FIG. **151**;

FIG. **154** is an elevational view of a deformable tube according to at least one embodiment;

FIG. **155** is a perspective cross-sectional view of the tissue thickness compensator of FIG. **151**;

FIG. **156** is a perspective cross-sectional view of a tissue thickness compensator in an end effector of a surgical instrument according to at least one embodiment;

FIG. **157** is a perspective view of a tissue thickness compensator according to at least one embodiment;

FIG. **158** is a partial elevational cross-sectional view of the tissue thickness compensator of FIG. **157** depicting a fastener engaged with tissue and with the tissue thickness compensator;

FIG. **159** is a perspective cross-sectional view of a tissue thickness compensator according to at least one embodiment;

FIG. **160** is an elevational view of a tissue thickness compensator according to at least one embodiment;

FIG. **161** is an elevational view of a tissue thickness compensator according to at least one embodiment;

FIG. **162** is an elevational view of a tissue thickness compensator positioned in a circular end effector of a surgical instrument according to at least one embodiment;

FIG. **163** is an elevational view of a tissue thickness compensator according to at least one embodiment;

FIG. **164** is an elevational view of a tissue thickness compensator according to at least one embodiment;

FIG. **165** is an elevational view of a tissue thickness compensator according to at least one embodiment;

FIG. **166** is an elevational view of a tissue thickness compensator according to at least one embodiment;

FIG. **167** is an elevational view of a tissue thickness compensator according to at least one embodiment;

FIG. **168** is a partial perspective view of a tissue thickness compensator according to at least one embodiment;

FIG. **169** is a partial perspective view of a tissue thickness compensator positioned in an end effector of a surgical instrument according to at least one embodiment;

FIG. **170** is a partial perspective view of a tissue thickness compensator with a fastener positioned in the apertures thereof according to at least one embodiment;

FIG. **171** is a partial perspective view of the tissue thickness compensator of FIG. **169** depicting the tissue thickness compensator in an undeformed configuration;

FIG. **172** is a partial perspective view of the tissue thickness compensator of FIG. **169** depicting the tissue thickness compensator in a partially deformed configuration;

FIG. **173** is a partial perspective view of the tissue thickness compensator of FIG. **169** depicting the tissue thickness compensator in a deformed configuration;

FIG. **174** is a perspective view of a tissue thickness compensator according to at least one embodiment;

FIG. **175** is a perspective view of an end effector of a stapling instrument comprising an anvil and a staple cartridge in accordance with at least one embodiment;

FIG. **176** is a cross-sectional view of the end effector of FIG. **175** illustrating staples positioned within the staple cartridge in an unfired state and a tissue thickness compensator comprising a sealed vessel in an unpunctured state, wherein the vessel is depicted with portions thereof removed for the purposes of illustration;

FIG. **177** is a cross-sectional view of the end effector of FIG. **175** illustrating the staples of FIG. **176** in an at least partially fired state and the vessel in an at least partially punctured state;

FIG. **178** is a perspective view of an end effector of a stapling instrument comprising an anvil and a staple cartridge in accordance with at least one embodiment;

FIG. **179** is a cross-sectional view of the end effector of FIG. **178** illustrating staples positioned within the staple cartridge in an unfired state and sealed vessels positioned within a tissue thickness compensator of the staple cartridge in an unpunctured state, wherein the vessels are depicted with portions thereof removed for the purposes of illustration;

FIG. **180** is a cross-sectional view of the end effector of FIG. **178** illustrating the staples of FIG. **179** in an at least partially fired state and the vessels in the staple cartridge in an at least partially punctured state;

FIG. **181** is a perspective view of an end effector of a stapling instrument comprising an anvil and a sealed vessel attached to the anvil in accordance with at least one alternative embodiment wherein the vessel is depicted with portions thereof removed for the purposes of illustration;

FIG. **182** is a cross-sectional view of the end effector of FIG. **181** illustrating staples at least partially fired from a staple cartridge and the vessels attached to the anvil in an at least partially punctured state;

FIG. **183** is a cross-sectional view of the vessel attached to the anvil of FIG. **181** illustrated in an expanded state;

FIG. **184** is a detail view of the vessel attached to the anvil of FIG. **183** illustrated in an expanded state;

FIG. **185** illustrates a vessel extending in a direction transverse to a line of staples;

FIG. **186** illustrates a plurality of vessels extending in directions which are transverse to a line of staples;

FIG. **187** is a cross-sectional view of a staple cartridge in accordance with various embodiments;

FIG. **188** is a partial cross-section view of FIG. **187** in an implanted condition;

FIG. **189**A is a partial perspective view of a tissue thickness compensator prior to expansion;

FIG. **189**B is a partial perspective view of a tissue thickness compensator of FIG. **189** during expansion;

FIG. **190** is a partial perspective view of a tissue thickness compensator comprising a fluid swellable composition according to various embodiments;

FIG. **191** is a cross-sectional view of tissue positioned adjacent a tissue thickness compensator according to various embodiments;

FIG. **192** is a partial cross-sectional view of FIG. **191** after the staple cartridge has been fired;

FIG. **193** is a diagram illustrating the tissue thickness compensator of FIG. **191** implanted adjacent the tissue;

FIG. **194** is a partial perspective view of a tissue thickness compensator according to various embodiments;

FIG. **195** is a perspective view of a jaw configured to receive the tissue thickness compensator of FIG. **194**;

FIG. **196** is a partial cross-sectional view of a staple cartridge illustrating staples being deployed from the staple cartridge;

FIG. **197** is a perspective view of an upper tissue thickness compensator and a lower tissue thickness compensator positioned within an effector of a disposable loading unit;

FIG. **198**A is a cross-sectional view of the lower tissue thickness compensator of FIG. **197** being manufactured in a mold in accordance with various embodiments;

FIG. **198**B is a cross-sectional view of a trilayer tissue thickness compensator being manufactured in a mold in accordance with various embodiments;

FIG. **199** is a cross-sectional view of an anvil comprising a tissue thickness compensator comprising reinforcement material in accordance with various embodiments;

FIG. **200** is cross-sectional view of a tissue positioned intermediate the upper tissue thickness compensator and lower tissue thickness compensator in accordance with various embodiments;

FIG. **201** is a cross-sectional view of FIG. **200** illustrating staples being deployed from the staple cartridge;

FIG. **202** is a cross-sectional view of FIG. **200** after the staple cartridge has been fired;

FIG. **203**A illustrates a needle configured to deliver a fluid to a tissue thickness compensator attached to a staple cartridge according to various embodiments;

FIG. **203**B is a cross-sectional view of a staple cartridge comprising a tissue thickness compensator configured to receive the needle of FIG. **203**A;

FIG. **204** illustrates a method of manufacturing a tissue thickness compensator according to various embodiments;

FIG. **205** is a diagram and a method of forming an expanding thickness compensator according to various embodiments;

FIG. **206** illustrates a micelle comprising a hydrogel precursor; and

FIG. **207** is a diagram of a surgical instrument comprising a tissue thickness compensator and fluids that may be delivered to the tissue thickness compensator according to various embodiments.

FIG. **208** is a partial perspective view of a tissue thickness compensator secured to an anvil of an end effector of a surgical instrument according to at least one embodiment.

FIG. **209** is a perspective view of a tubular element of the tissue thickness compensator of FIG. **208**.

FIG. **210** is a perspective view of the tubular element of FIG. **209** depicting the tubular element severed into two halves and fluid contacting the hydrophilic substance within each half.

FIG. **211** is a perspective view of a half of the severed tubular element of FIG. **210** depicting expansion of the severed tubular element.

Corresponding reference characters indicate corresponding parts throughout the several views. The exemplifications set out herein illustrate certain embodiments of the invention, in one form, and such exemplifications are not to be construed as limiting the scope of the invention in any manner.

DETAILED DESCRIPTION

The Applicant of the present application also owns the U.S. Patent Applications identified below which are each herein incorporated by reference in their respective entirety:

U.S. patent application Ser. No. 12/894,311, entitled SURGICAL INSTRUMENTS WITH RECONFIGURABLE SHAFT SEGMENTS, now U.S. Patent Application Publication No. 2012/0080496;

U.S. patent application Ser. No. 12/894,340, entitled SURGICAL STAPLE CARTRIDGES SUPPORTING NON-LINEARLY ARRANGED STAPLES AND SURGICAL STAPLING INSTRUMENTS WITH COMMON STAPLE-FORMING POCKETS, now U.S. Patent Application Publication No. 2012/0080482;

U.S. patent application Ser. No. 12/894,327, entitled JAW CLOSURE ARRANGEMENTS FOR SURGICAL INSTRUMENTS, now U.S. Patent Application Publication No. 2012/0080499;

U.S. patent application Ser. No. 12/894,351, entitled SURGICAL CUTTING AND FASTENING INSTRUMENTS WITH SEPARATE AND DISTINCT FASTENER DEPLOYMENT AND TISSUE CUTTING SYSTEMS, now U.S. Patent Application Publication No. 2012/0080502;

U.S. patent application Ser. No. 12/894,338, entitled IMPLANTABLE FASTENER CARTRIDGE HAVING A NON-UNIFORM ARRANGEMENT, now U.S. Patent Application Publication No. 2012/0080481;

U.S. patent application Ser. No. 12/894,369, entitled IMPLANTABLE FASTENER CARTRIDGE COMPRISING A SUPPORT RETAINER, now U.S. Patent Application Publication No. 2012/0080344;

U.S. patent application Ser. No. 12/894,312, entitled IMPLANTABLE FASTENER CARTRIDGE COMPRISING MULTIPLE LAYERS, now U.S. Patent Application Publication No. 2012/0080479;

U.S. patent application Ser. No. 12/894,377, entitled SELECTIVELY ORIENTABLE IMPLANTABLE FASTENER CARTRIDGE, now U.S. Pat. No. 8,393,514;

U.S. patent application Ser. No. 12/894,339, entitled SURGICAL STAPLING INSTRUMENT WITH COMPACT ARTICULATION CONTROL ARRANGEMENT, now U.S. Patent Application Publication No. 2012/0080500;

U.S. patent application Ser. No. 12/894,360, entitled SURGICAL STAPLING INSTRUMENT WITH A VARIABLE STAPLE FORMING SYSTEM, now U.S. Patent Application Publication No. 2012/0080484;

U.S. patent application Ser. No. 12/894,322, entitled SURGICAL STAPLING INSTRUMENT WITH INTERCHANGEABLE STAPLE CARTRIDGE ARRANGEMENTS, now U.S. Patent Application Publication No. 2012/0080501;

U.S. patent application Ser. No. 12/894,350, entitled SURGICAL STAPLE CARTRIDGES WITH DETACHABLE SUPPORT STRUCTURES AND SURGICAL STAPLING INSTRUMENTS WITH SYSTEMS FOR PREVENTING ACTUATION MOTIONS WHEN A CARTRIDGE IS NOT PRESENT, now U.S. Patent Application No. 2012/0080478;

U.S. patent application Ser. No. 12/894,383, entitled IMPLANTABLE FASTENER CARTRIDGE COMPRISING BIOABSORBABLE LAYERS, now U.S. Patent Application No. 2012/0080345;

U.S. patent application Ser. No. 12/894,389, entitled COMPRESSIBLE FASTENER CARTRIDGE, now U.S. Patent Application Publication No. 2012/0080335;

U.S. patent application Ser. No. 12/894,345, entitled FASTENERS SUPPORTED BY A FASTENER CARTRIDGE SUPPORT, now U.S. Patent Application Publication No. 2012/0080483;

U.S. patent application Ser. No. 12/894,306, entitled COLLAPSIBLE FASTENER CARTRIDGE, now U.S. Patent Application Publication No. 2012/0080332;

U.S. patent application Ser. No. 12/894,318, entitled FASTENER SYSTEM COMPRISING A PLURALITY OF CONNECTED RETENTION MATRIX ELEMENTS, now U.S. Patent Application Publication No. 2012/0080480;

U.S. patent application Ser. No. 12/894,330, entitled FASTENER SYSTEM COMPRISING A RETENTION MATRIX AND AN ALIGNMENT MATRIX, now U.S. Patent Application Publication No. 2012/0080503;

U.S. patent application Ser. No. 12/894,361, entitled FASTENER SYSTEM COMPRISING A RETENTION MATRIX, now U.S. Pat. No. 8,529,600;

U.S. patent application Ser. No. 12/894,367, entitled FASTENING INSTRUMENT FOR DEPLOYING A FASTENER SYSTEM COMPRISING A RETENTION MATRIX, now U.S. Patent Application Publication No. 2012/0080485;

U.S. patent application Ser. No. 12/894,388, entitled FASTENER SYSTEM COMPRISING A RETENTION MATRIX AND A COVER, now U.S. Pat. No. 8,474,677;

U.S. patent application Ser. No. 12/894,376, entitled FASTENER SYSTEM COMPRISING A PLURALITY OF FASTENER CARTRIDGES, now U.S. Patent Application Publication No. 2012/0080486;

U.S. patent application Ser. No. 13/097,865, entitled SURGICAL STAPLER ANVIL COMPRISING A PLURALITY OF FORMING POCKETS, now U.S. Patent Application Publication No. 2012/0080488;

U.S. patent application Ser. No. 13/097,936, entitled TISSUE THICKNESS COMPENSATOR FOR A SURGICAL STAPLER, now U.S. Patent Application Publication No. 2012/0080339;

U.S. patent application Ser. No. 13/097,954, entitled STAPLE CARTRIDGE COMPRISING A VARIABLE THICKNESS COMPRESSIBLE PORTION, now U.S. Patent Application Publication No. 2012/0080340;

U.S. patent application Ser. No. 13/097,856, entitled STAPLE CARTRIDGE COMPRISING STAPLES POSITIONED WITHIN A COMPRESSIBLE PORTION THEREOF, now U.S. Patent Application Publication No. 2012/0080336;

U.S. patent application Ser. No. 13/097,928, entitled TISSUE THICKNESS COMPENSATOR COMPRISING DETACHABLE PORTIONS, now U.S. Patent Application Publication No. 2012/0080490;

U.S. patent application Ser. No. 13/097,891, entitled TISSUE THICKNESS COMPENSATOR FOR A SURGICAL STAPLER COMPRISING AN ADJUSTABLE ANVIL, now U.S. Patent Application Publication No. 2012/0080489;

U.S. patent application Ser. No. 13/097,948, entitled STAPLE CARTRIDGE COMPRISING AN ADJUSTABLE DISTAL PORTION, now U.S. Patent Application Publication No. 2012/0083836;

U.S. patent application Ser. No. 13/097,907, entitled COMPRESSIBLE STAPLE CARTRIDGE ASSEMBLY, now U.S. Patent Application Publication No. 2012/0080338;

U.S. patent application Ser. No. 13/097,861, entitled TISSUE THICKNESS COMPENSATOR COMPRISING PORTIONS HAVING DIFFERENT PROPERTIES, U.S. Patent Application Publication No. 2012/0080337;

U.S. patent application Ser. No. 13/097,869, entitled STAPLE CARTRIDGE LOADING ASSEMBLY, now U.S. Patent Application Publication No. 2012/0160721;

U.S. patent application Ser. No. 13/097,917, entitled COMPRESSIBLE STAPLE CARTRIDGE COMPRISING ALIGNMENT MEMBERS, now U.S. Patent Application No. 2012/0083834;

U.S. patent application Ser. No. 13/097,873, entitled STAPLE CARTRIDGE COMPRISING A RELEASABLE PORTION, now U.S. Patent Application Publication No. 2012/0083833;

U.S. patent application Ser. No. 13/097,938, entitled STAPLE CARTRIDGE COMPRISING COMPRESSIBLE DISTORTION RESISTANT COMPONENTS, now U.S. Patent Application Publication No. 2012/0080491;

U.S. patent application Ser. No. 13/097,924, entitled STAPLE CARTRIDGE COMPRISING A TISSUE THICKNESS COMPENSATOR, now U.S. Patent Application Publication No. 2012/0083835;

U.S. patent application Ser. No. 13/242,029, entitled SURGICAL STAPLER WITH FLOATING ANVIL, now U.S. Patent Application Publication No. 2012/0080493;

U.S. patent application Ser. No. 13/242,066, entitled CURVED END EFFECTOR FOR A STAPLING INSTRUMENT, now U.S. Patent Application Publication No. 2012/0080498;

U.S. patent application Ser. No. 13/242,086, entitled STAPLE CARTRIDGE INCLUDING COLLAPSIBLE DECK, now U.S. Patent Application Publication No. 2013/0075450;

U.S. patent application Ser. No. 13/241,912, entitled STAPLE CARTRIDGE INCLUDING COLLAPSIBLE DECK ARRANGEMENT, now U.S. Patent Application Publication No. 2013/0075448;

U.S. patent application Ser. No. 13/241,922, entitled SURGICAL STAPLER WITH STATIONARY STAPLE DRIVERS, now U.S. Patent Application Publication No. 2013/0075449;

U.S. patent application Ser. No. 13/241,637, entitled SURGICAL INSTRUMENT WITH TRIGGER ASSEMBLY FOR GENERATING MULTIPLE ACTUATION MOTIONS, now U.S. Patent Application Publication No. 2012/0074201; and

U.S. patent application Ser. No. 13/241,629, entitled SURGICAL INSTRUMENT WITH SELECTIVELY ARTICULATABLE END EFFECTOR, now U.S. Patent Application Publication No. 2012/0074200.

The Applicant of the present application also owns the U.S. Patent Applications identified below which were filed on Mar. 28, 2012 and which are each herein incorporated by reference in their respective entirety:

U.S. patent application Ser. No. 13/433,096, entitled TISSUE THICKNESS COMPENSATOR COMPRISING A PLURALITY OF CAPSULES, now U.S. Patent Application Publication No. 2012/0241496;

U.S. patent application Ser. No. 13/433,103, entitled TISSUE THICKNESS COMPENSATOR COMPRISING A PLURALITY OF LAYERS, now U.S. Patent Application Publication No. 2012/0241498;

U.S. patent application Ser. No. 13/433,098, entitled EXPANDABLE TISSUE THICKNESS COMPENSATOR, now U.S. Patent Application Publication No. 2012/0241491;

U.S. patent application Ser. No. 13/433,102, entitled TISSUE THICKNESS COMPENSATOR COMPRISING A RESERVOIR, now U.S. Patent Application Publication No. 2012/0241497;

U.S. patent application Ser. No. 13/433,114, entitled RETAINER ASSEMBLY INCLUDING A TISSUE THICKNESS COMPENSATOR, now U.S. Patent Application Publication No. 2012/0241499;

U.S. patent application Ser. No. 13/433,136, entitled TISSUE THICKNESS COMPENSATOR COMPRISING AT LEAST ONE MEDICAMENT, now U.S. Patent Application Publication No. 2012/0241492;

U.S. patent application Ser. No. 13/433,141, entitled TISSUE THICKNESS COMPENSATOR COMPRISING CONTROLLED RELEASE AND EXPANSION, now U.S. Patent Application Publication No. 2012/0241493;

U.S. patent application Ser. No. 13/433,144, entitled TISSUE THICKNESS COMPENSATOR COMPRISING FIBERS TO PRODUCE A RESILIENT LOAD, now U.S. Patent Application Publication Serial No. 2012/0241500;

U.S. patent application Ser. No. 13/433,155, entitled TISSUE THICKNESS COMPENSATOR COMPRISING RESILIENT MEMBERS, now U.S. Patent Application Publication No. 2012/0241502;

U.S. patent application Ser. No. 13/433,163, entitled METHODS FOR FORMING TISSUE THICKNESS COMPENSATOR ARRANGEMENTS FOR SURGICAL STAPLERS, now U.S. Patent Application Publication No. 2012/0248169;

U.S. patent application Ser. No. 13/433,167, entitled TISSUE THICKNESS COMPENSATORS, now U.S. Patent Application Publication No. 2012/0241503;

U.S. patent application Ser. No. 13/433,175, entitled LAYERED TISSUE THICKNESS COMPENSATOR, now U.S. Patent Application Publication No. 2012/0253298;

U.S. patent application Ser. No. 13/433,179, entitled TISSUE THICKNESS COMPENSATORS FOR CIRCULAR SURGICAL STAPLERS, now U.S. Patent Application Publication No. 2012/0241505;

U.S. patent application Ser. No. 13/433,115, entitled TISSUE THICKNESS COMPENSATOR COMPRISING CAPSULES DEFINING A LOW PRESSURE ENVIRONMENT, now U.S. Patent Application Publication No. 2013/0256372;

U.S. patent application Ser. No. 13/433,118, entitled TISSUE THICKNESS COMPENSATOR COMPRISED OF A PLURALITY OF MATERIALS, now U.S. Patent Application Publication No. 2013/0256365;

U.S. patent application Ser. No. 13/433,135, entitled MOVABLE MEMBER FOR USE WITH A TISSUE THICKNESS COMPENSATOR, U.S. Patent Application Publication No. 2013/0256382;

U.S. patent application Ser. No. 13/433,129, entitled TISSUE THICKNESS COMPENSATOR COMPRISING A PLURALITY OF MEDICAMENTS, now U.S. Patent Application Publication No. 2013/0256367;

U.S. patent application Ser. No. 13/433,140, entitled TISSUE THICKNESS COMPENSATOR AND METHOD FOR MAKING THE SAME, now U.S. Patent Application Publication No. 2013/0256368;

U.S. patent application Ser. No. 13/433,147, entitled TISSUE THICKNESS COMPENSATOR COMPRISING CHANNELS, now U.S. Patent Application Publication No. 2013/0256369;

U.S. patent application Ser. No. 13/433,126, entitled TISSUE THICKNESS COMPENSATOR COMPRISING TISSUE INGROWTH FEATURES, now U.S. Patent Application Publication No. 2013/0256366; and

U.S. patent application Ser No. 13/433,132, entitled DEVICES AND METHODS FOR ATTACHING TISSUE THICKNESS COMPENSATING MATERIALS TO SURGICAL STAPLING INSTRUMENTS, now U.S. Patent Application Publication No. 2013/0256373.

Certain exemplary embodiments will now be described to provide an overall understanding of the principles of the structure, function, manufacture, and use of the devices and methods disclosed herein. One or more examples of these embodiments are illustrated in the accompanying drawings. Those of ordinary skill in the art will understand that the devices and methods specifically described herein and illustrated in the accompanying drawings are non-limiting exemplary embodiments and that the scope of the various embodiments of the present invention is defined solely by the claims. The features illustrated or described in connection with one exemplary embodiment may be combined with the features of other embodiments. Such modifications and variations are intended to be included within the scope of the present invention.

Reference throughout the specification to "various embodiments," "some embodiments," "one embodiment," or "an embodiment", or the like, means that a particular feature, structure, or characteristic described in connection with the embodiment is included in at least one embodiment. Thus, appearances of the phrases "in various embodiments," "in some embodiments," "in one embodiment", or "in an embodiment", or the like, in places throughout the specification are not necessarily all referring to the same embodiment. Furthermore, the particular features, structures, or characteristics may be combined in any suitable manner in one or more embodiments. Thus, the particular features, structures, or characteristics illustrated or described in connection with one embodiment may be combined, in whole or in part, with the features structures, or characteristics of one or more other embodiments without limitation. Such modifications and variations are intended to be included within the scope of the present invention.

The terms "proximal" and "distal" are used herein with reference to a clinician manipulating the handle portion of the surgical instrument. The term "proximal" referring to the portion closest to the clinician and the term "distal" referring to the portion located away from the clinician. It will be further appreciated that, for convenience and clarity, spatial terms such as "vertical", "horizontal", "up", and "down" may be used herein with respect to the drawings. However, surgical instruments are used in many orientations and positions, and these terms are not intended to be limiting and/or absolute.

Various exemplary devices and methods are provided for performing laparoscopic and minimally invasive surgical procedures. However, the person of ordinary skill in the art will readily appreciate that the various methods and devices disclosed herein can be used in numerous surgical procedures and applications including, for example, in connection with open surgical procedures. As the present Detailed Description proceeds, those of ordinary skill in the art will further appreciate that the various instruments disclosed herein can be inserted into a body in any way, such as through a natural orifice, through an incision or puncture hole formed in tissue, etc. The working portions or end effector portions of the instruments can be inserted directly into a patient's body or can be inserted through an access device that has a working channel through which the end effector and elongated shaft of a surgical instrument can be advanced.

Turning to the Drawings wherein like numerals denote like components throughout the several views, FIG. **1** depicts a surgical instrument **10** that is capable of practicing several unique benefits. The surgical stapling instrument **10** is designed to manipulate and/or actuate various forms and sizes of end effectors **12** that are operably attached thereto. In the embodiment depicted in FIGS. **1**-**1**E, for example, the end effector **12** includes an elongated channel **14** that forms a lower jaw **13** of the end effector **12**. The elongated channel **14** is configured to support an "implantable" staple cartridge **30** and also movably support an anvil **20** that functions as an upper jaw **15** of the end effector **12**.

In various embodiments, the elongated channel **14** may be fabricated from, for example, 300 & 400 Series, 17-4 & 17-7 stainless steel, titanium, etc. and be formed with spaced side walls **16**. The anvil **20** may be fabricated from, for example, 300 & 400 Series, 17-4 & 17-7 stainless steel, titanium, etc. and have a staple forming undersurface, generally labeled as **22** that has a plurality of staple forming pockets **23** formed therein. See FIGS. **1**B-**1**E. In addition, the anvil **20** has a bifurcated ramp assembly **24** that protrudes proximally therefrom. An anvil pin **26** protrudes from each lateral side of the ramp assembly **24** to be received within a corresponding slot or opening **18** in the side walls **16** of the elongated channel **14** to facilitate its movable or pivotable attachment thereto.

Various forms of implantable staple cartridges may be employed with the various embodiments of the surgical instruments disclosed herein. Specific staple cartridge configurations and constructions will be discussed in further detail below. However, in the embodiment depicted in FIG. **1**A, an implantable staple cartridge **30** is shown. In at least one embodiment, the staple cartridge **30** has a body portion **31** that consists of a compressible hemostat material such as, for example, oxidized regenerated cellulose ("ORC") or a bioabsorbable foam in which lines of unformed metal staples **32** are supported. In at least some embodiments, in order to prevent the staple from being affected and the hemostat material from being activated during the introduction and positioning process, the entire cartridge may be coated or wrapped in a biodegradable film **38** such as a polydioxanon film sold under the trademark PDS® or with a Polyglycerol sebacate (PGS) film or other biodegradable films formed from PGA (Polyglycolic acid, marketed under the trade mark Vicryl), PCL (Polycaprolactone), PLA or PLLA (Polylactic acid), PHA (polyhydroxyalkanoate), PGCL (poliglecaprone **25**, sold under the trademark Monocryl) or a composite of PGA, PCL, PLA, PDS that would be impermeable until ruptured. The body **31** of staple cartridge **30** is sized to be removably supported within the elongated channel **14** as shown such that each staple **32** therein is aligned with corresponding staple forming pockets **23** in the anvil when the anvil **20** is driven into forming contact with the staple cartridge **30**.

In use, once the end effector **12** has been positioned adjacent the target tissue, the end effector **12** is manipulated to capture or clamp the target tissue between an upper face **36** of the staple cartridge **30** and the staple forming surface **22** of the anvil **20**. The staples **32** are formed by moving the anvil **20** in a path that is substantially parallel to the elongated channel **14** to bring the staple forming surface **22** and, more particularly, the staple forming pockets **23** therein into substantially simultaneous contact with the upper face **36** of the staple cartridge **30**. As the anvil **20** continues to move into the staple cartridge **30**, the legs **34** of the staples **32** contact a corresponding staple forming pocket **23** in anvil **20** which serves to bend the staple legs **34** over to form the staples **32** into a "B shape". Further movement of the anvil **20** toward the elongated channel **14** will further compress and form the staples **32** to a desired final formed height "FF".

The above-described staple forming process is generally depicted in FIGS. **1**B-**1**E. For example, FIG. **1**B illustrates the end effector **12** with target tissue "T" between the anvil **20** and the upper face **36** of the implantable staple cartridge **30**. FIG. **1**C illustrates the initial clamping position of the anvil **20** wherein the anvil has **20** been closed onto the target tissue "T" to clamp the target tissue "T" between the anvil **20** and the upper face **36** of the staple cartridge **30**. FIG. **1**D illustrates the initial staple formation wherein the anvil **20** has started to compress the staple cartridge **30** such that the legs **34** of the staples **32** are starting to be formed by the staple forming pockets **23** in the anvil **20**. FIG. **1**E illustrates the staple **32** in its final formed condition through the target tissue "T" with the anvil **20** removed for clarity purposes. Once the staples **32** have been formed and fastened to the target tissue "T", the surgeon will move the anvil **20** to the open position to enable the cartridge body **31** and the staples **32** to remain affixed to the target tissue while the end effector **12** is being withdrawn from the patient. The end effector **12** forms all of the staples simultaneously as the two jaws **13**, **15** are clamped together. The remaining "crushed" body materials **31** act as both a hemostat (the ORC) and a staple line reinforcement (PGA, PDS or any of the other film compositions mentioned above **38**). Also, since the staples **32** never have to leave the cartridge body **31** during forming, the likelihood of the staples **32** being malformed during forming is minimized. As used herein the term "implantable" means that, in addition to the staples, the cartridge body materials that support the staples will also remain in the patient and may eventually be absorbed by the patient's body. Such implantable staple cartridges are distinguishable from prior cartridge arrangements that remain positioned within the end effector in their entirety after they have been fired.

In various implementations, the end effector **12** is configured to be coupled to an elongated shaft assembly **40** that protrudes from a handle assembly **100**. The end effector **12** (when closed) and the elongated shaft assembly **40** may have similar cross-sectional shapes and be sized to operably pass through a trocar tube or working channel in another form of access instrument. As used herein, the term "operably pass" means that the end effector and at least a portion of the elongated shaft assembly may be inserted through or passed through the channel or tube opening and can be manipulated therein as needed to complete the surgical stapling procedure. In some embodiments, when in a closed position, the jaws **13** and **15** of the end effector **12** may provide the end effector with a roughly circular cross-sectional shape that facilitates its passage through a circular passage/opening. However, the end effectors of various embodiments of the present invention, as well as the elongated shaft assembly embodiments, could conceivably be provided with other cross-sectional shapes that could otherwise pass through access passages and openings that have non-circular cross-sectional shapes. Thus, an overall size of a cross-section of a closed end effector will be related to the size of the passage or opening through which it is intended to pass. Thus, one end effector for example, may be referred to as a "5 mm" end effector which means it can operably pass through an opening that is at least approximately 5 mm in diameter.

In various embodiments, the elongated shaft assembly **40** may have an outer diameter that is substantially the same as the outer diameter of the end effector **12** when in a closed position. For example, a 5 mm end effector may be coupled to an elongated shaft assembly **40** that has 5 mm cross-sectional diameter. However, as the present Detailed Description proceeds, it will become apparent that various embodiments of the present may be effectively used in connection with different sizes of end effectors. For example, a 10 mm end effector may be attached to an elongated shaft that has a 5 mm cross-sectional diameter. Conversely, for those applications wherein a 10 mm or larger access opening or passage is provided, the elongated shaft assembly **40** may have a 10 mm (or larger) cross-sectional diameter, but may also be able to actuate a 5 mm or 10 mm end effector. Accordingly, the outer shaft **40** may have an outer diameter that is the same as or is different from the outer diameter of a closed end effector **12** attached thereto.

As depicted, the elongated shaft assembly **40** extends distally from the handle assembly **100** in a generally straight line to define a longitudinal axis A-A. In various embodiments, for example, the elongated shaft assembly **40** may be approximately 9-16 inches (229-406 mm) long. However, the elongated shaft assembly **40** may be provided in other lengths and, in other embodiments, may have joints therein or be otherwise configured to facilitate articulation of the end effector **12** relative to other portions of the shaft or handle assembly as will be discussed in further detail below. In various embodiments, the elongated shaft assembly **40** includes a spine member **50** that extends from the handle assembly **100** to the end effector **12**. The proximal end of the elongated channel **14** of the end effector **12** has a pair of retention trunnions **17** protruding therefrom that are sized to be received within corresponding trunnion openings or cradles **52** that are provided in a distal end of the spine member **50** to enable the end effector **12** to be removably coupled the elongated shaft assembly **40**. The spine member **50** may be fabricated from, for example, 6061 or 7075 aluminum, stainless steel, titanium, etc.

In various embodiments, the handle assembly **100** comprises a pistol grip-type housing that may be fabricated in two or more pieces for assembly purposes. For example, the handle assembly **100** as shown comprises a right hand case member **102** and a left hand case member (not illustrated) that are molded or otherwise fabricated from a polymer or plastic material and are designed to mate together. Such case members may be attached together by snap features, pegs and sockets molded or otherwise formed therein and/or by adhesive, screws, etc. The spine member **50** has a proximal end **54** that has a flange **56** formed thereon. The flange **56** is configured to be rotatably supported within a groove **106** formed by mating ribs **108** that protrude inwardly from each of the case members **102**, **104**. Such arrangement facilitates the attachment of the spine member **50** to the handle assembly **100** while enabling the spine member **50** to be rotated relative to the handle assembly **100** about the longitudinal axis A-A in a 360° path.

As can be further seen in FIG. **1**, the spine member **50** passes through and is supported by a mounting bushing **60** that is rotatably affixed to the handle assembly **100**. The mounting bushing **60** has a proximal flange **62** and a distal flange **64** that define a rotational groove **65** that is configured to rotatably receive a nose portion **101** of the handle assembly **100** therebetween. Such arrangement enables the mounting bushing **60** to rotate about longitudinal axis A-A relative to the handle assembly **100**. The spine member **50** is non-rotatably pinned to the mounting bushing **60** by a spine pin **66**. In addition, a rotation knob **70** is attached to the mounting bushing **60**. In one embodiment, for example, the rotation knob **70** has a hollow mounting flange portion **72** that is sized to receive a portion of the mounting bushing **60** therein. In various embodiments, the rotation knob **70** may be fabricated from, for example, glass or carbon filled Nylon, polycarbonate, Ultem®, etc. and is affixed to the mounting bushing **60** by the spine pin **66** as well. In addition, an inwardly protruding retention flange **74** is formed on the mounting flange portion **72** and is configured to extend into a radial groove **68** formed in the mounting bushing **60**. Thus, the surgeon may rotate the spine member **50** (and the end effector **12** attached thereto) about longitudinal axis A-A in a 360° path by grasping the rotation knob **70** and rotating it relative to the handle assembly **100**.

In various embodiments, the anvil **20** is retained in an open position by an anvil spring **21** and/or another biasing arrangement. The anvil **20** is selectively movable from the open position to various closed or clamping and firing positions by a firing system, generally designated as **109**. The firing system **109** includes a "firing member" **110** which, in various embodiments, comprises a hollow firing tube **110**. The hollow firing tube **110** is axially movable on the spine member **50** and thus forms the outer portion of the elongated shaft assembly **40**. The firing tube **110** may be fabricated from a polymer or other suitable material and have a proximal end that is attached to a firing yoke **114** of the firing system **109**. In various embodiments for example, the firing yoke **114** may be over-molded to the proximal end of the firing tube **110**. However, other fastener arrangements may be employed.

As can be seen in FIG. **1**, the firing yoke **114** may be rotatably supported within a support collar **120** that is configured to move axially within the handle assembly **100**. In various embodiments, the support collar **120** has a pair of laterally extending fins that are sized to be slidably received within fin slots formed in the right and left hand case members. Thus, the support collar **120** may slide axially within the handle housing **100** while enabling the firing yoke **114** and firing tube **110** to rotate relative thereto about the longitudinal axis A-A. In various embodiments, a longitudinal slot is provided through the firing tube **110** to enable the spine pin **66** to extend therethrough into the spine member **50** while facilitating the axial travel of the firing tube **110** on the spine member **50**.

The firing system **109** further comprises a firing trigger **130** which serves to control the axial travel of the firing tube **110** on the spine member **50**. See FIG. **1**. Such axial movement in the distal direction of the firing tube **110** into firing interaction with the anvil **20** is referred to herein as "firing motion". As can be seen in FIG. **1**, the firing trigger **130** is movably or pivotally coupled to the handle assembly **100** by a pivot pin **132**. A torsion spring **135** is employed to bias the firing trigger **130** away from the pistol grip portion **107** of the handle assembly **100** to an un-actuated "open" or starting position. As can be seen in FIG. **1**, the firing trigger **130** has an upper portion **134** that is movably attached to (pinned) firing links **136** that are movably attached to (pinned) the support collar **120**. Thus, movement of the firing trigger **130** from the starting position (FIG. **1**) toward an ending position adjacent the pistol grip portion **107** of the handle assembly **100** will cause the firing yoke **114** and the firing tube **110** to move in the distal direction "DD". Movement of the firing trigger **130** away from the pistol grip portion **107** of the handle assembly **100** (under the bias of the torsion spring **135**) will cause the firing yoke **114** and firing tube **110** to move in the proximal direction "PD" on the spine member **50**.

Various embodiments of the present invention may be employed with different sizes and configurations of implantable staple cartridges. For example, the surgical instrument **10**, when used in connection with a first firing adapter **140**, may be used with a 5 mm end effector **12** that is approximately 20 mm long (or in other lengths) which supports an implantable staple cartridge **30**. Such end effector size may be particularly well-suited, for example, to complete relatively fine dissection and vascular transactions. However, as will be discussed in further detail below, the surgical instrument **10** may also be employed, for example, in connection with other sizes of end effectors and staple cartridges by replacing the first firing adapter **140** with a second firing adapter. In still other embodiments, the elongated shaft assembly **40** may configured to be attached to only one form or size of end effector.

One method of removably coupling the end effector **12** to the spine member **50** will now be explained. The coupling process is commenced by inserting the retention trunnions **17** on the elongated channel **14** into the trunnion cradles **52** in the spine member **50**. Thereafter, the surgeon advances the firing trigger **130** toward the pistol grip **107** of the housing assembly **100** to distally advance the firing tube **110** and the first firing adapter **140** over a proximal end portion **47** of the elongated channel **14** to thereby retain the trunnions **17** in their respective cradles **52**. Such position of the first firing adapter **140** over the trunnions **17** is referred to herein as the "coupled position". Various embodiments of the present invention may also have an end effector locking assembly for locking the firing trigger **130** in position after an end effector **12** has been attached to the spine member **50**.

More specifically, one embodiment of the end effector locking assembly **160** includes a retention pin **162** that is movably supported in the upper portion **134** of the firing trigger **130**. As discussed above, the firing tube **110** must initially be advanced distally to the coupled position wherein the first firing adapter **140** retains the retention trunnions **17** of the end effector **12** in the trunnion cradles **52** in the spine member **50**. The surgeon advances the firing adapter **140** distally to the coupled position by pulling the firing trigger **130** from the starting position toward the pistol grip **107**. As the firing trigger **130** is initially actuated, the retention pin **162** is moved distally until the firing tube **110** has advanced the first firing adapter **140** to the coupled position at which point the retention pin **162** is biased into a locking cavity **164** formed in the case member. In various embodiments, when the retention pin **162** enters into the locking cavity **164**, the pin **162** may make an audible "click" or other sound, as well as provide a tactile indication to the surgeon that the end effector **12** has been "locked" onto the spine member **50**. In addition, the surgeon cannot inadvertently continue to actuate the firing trigger **130** to start to form staples **32** in the end effector **12** without intentionally biasing the retention pin **162** out of the locking cavity **164**. Similarly, if the surgeon releases the firing trigger **130** when in the coupled position, it is retained in that position by the retention pin **162** to prevent the firing trigger **130** from returning to the starting position and thereby releasing the end effector **12** from the spine member **50**.

Various embodiments of the present invention may further include a firing system lock button **137** that is pivotally attached to the handle assembly **100**. In one form, the firing system lock button **137** has a latch **138** formed on a distal end thereof that is oriented to engage the firing yoke **114** when the firing release button is in a first latching position. As can be seen in FIG. **1**, a latch spring **139** serves to bias the firing system lock button **137** to the first latching position. In various circumstances, the latch **138** serves to engage the firing yoke **114** at a point where the position of the firing yoke **114** on the spine member **50** corresponds to a point wherein the first firing adapter **140** is about to distally advance up the clamping ramp **28** on the anvil **20**. It will be understood that, as the first firing adapter **140** advances axially up the clamping ramp **28**, the anvil **20** will move in a path such that its staple forming surface portion **22** is substantially parallel to the upper face **36** of the staple cartridge **30**.

After the end effector **12** has been coupled to the spine member **50**, the staple forming process is commenced by first depressing the firing system lock button **137** to enable the firing yoke **114** to be further moved distally on the spine member **50** and ultimately compress the anvil **20** into the staple cartridge **30**. After depressing the firing system lock button **137**, the surgeon continues to actuate the firing trigger **130** towards the pistol grip **107** thereby driving the first staple collar **140** up the corresponding staple forming ramp **29** to force the anvil **20** into forming contact with the staples **32** in the staple cartridge **30**. The firing system lock button **137** prevents the inadvertent forming of the staples **32** until the surgeon is ready to start that process. In this embodiment, the surgeon must depress the firing system lock button **137** before the firing trigger **130** may be further actuated to begin the staple forming process.

The surgical instrument **10** may be solely used as a tissue stapling device if so desired. However, various embodiments of the present invention may also include a tissue cutting system, generally designated as **170**. In at least one form, the tissue cutting system **170** comprises a knife member **172** that may be selectively advanced from an un-actuated position adjacent the proximal end of the end effector **12** to an actuated position by actuating a knife advancement trigger **200**. The knife member **172** is movably supported within the spine member **50** and is attached or otherwise protrudes from a knife rod **180**. The knife member **172** may be fabricated from, for example, 420 or 440 stainless steel with a hardness of greater than 38HRC (Rockwell Hardness C-scale) and have a tissue cutting edge **176** formed on the distal end **174** thereof and be configured to slidably extend through a slot in the anvil **20** and a centrally disposed slot **33** in the staple cartridge **30** to cut through tissue that is clamped in the end effector **12**. In various embodiments, the knife rod **180** extends through the spine member **50** and has a proximal end portion which drivingly interfaces with a knife transmission that is operably attached to the knife advance trigger **200**. In various embodiments, the knife advance trigger **200** is attached to pivot pin **132** such that it may be pivoted or otherwise actuated without actuating the firing trigger **130**. In various embodiments, a first knife gear **192** is also attached to the pivot pin **132** such that actuation of the knife advance trigger **200** also pivots the first knife gear **192**. A firing return spring **202** is attached between the first knife gear **192** and the handle housing **100** to bias the knife advancement trigger **200** to a starting or un-actuated position.

Various embodiments of the knife transmission also include a second knife gear **194** that is rotatably supported on a second gear spindle and in meshing engagement with the first knife gear **192**. The second knife gear **194** is in meshing engagement with a third knife gear **196** that is supported on a third gear spindle. Also supported on the third gear spindle **195** is a fourth knife gear **198**. The fourth knife gear **198** is adapted to drivingly engage a series of annular gear teeth or rings on a proximal end of the knife rod **180**. Thus, such arrangement enables the fourth knife gear **198** to axially drive the knife rod **180** in the distal direction "DD" or proximal direction "PD" while enabling the firing rod **180** to rotate about longitudinal axis A-A with respect to the fourth knife gear **198**. Accordingly, the surgeon may axially advance the firing rod **180** and ultimately the knife member **172** distally by pulling the knife advancement trigger **200** towards the pistol grip **107** of the handle assembly **100**.

Various embodiments of the present invention further include a knife lockout system **210** that prevents the advancement of the knife member **172** unless the firing trigger **130** has been pulled to the fully fired position. Such feature will therefore prevent the activation of the knife advancement system **170** unless the staples have first been fired or formed into the tissue. As can be seen in FIG. **1**, various implementations of the knife lockout system **210** comprise a knife lockout bar **211** that is pivotally supported within the pistol grip portion **107** of the handle assembly **100**. The knife lockout bar **211** has an activation end **212** that is adapted to be engaged by the firing trigger **130** when the firing trigger **130** is in the fully fired position. In addition, the knife lockout bar **211** has a retaining hook **214** on its other end that is adapted to hookingly engage a latch rod **216** on the first cut gear **192**. A knife lock spring **218** is employed to bias the knife lockout bar **211** to a "locked" position wherein the retaining hook **214** is retained in engagement with the latch rod **216** to thereby prevent actuation of the knife advancement trigger **200** unless the firing trigger **130** is in the fully fired position.

After the staples have been "fired" (formed) into the target tissue, the surgeon may depress the firing trigger release button **167** to enable the firing trigger **130** to return to the starting position under the bias of the torsion spring **135** which enables the anvil **20** to be biased to an open position under the bias of spring **21**. When in the open position, the surgeon may withdraw the end effector **12** leaving the implantable staple cartridge **30** and staples **32** behind. In applications wherein the end effector was inserted through a passage, working channel, etc. the surgeon will return the anvil **20** to the closed position by activating the firing trigger **130** to enable the end effector **12** to be withdrawn out through the passage or working channel. If, however, the surgeon desires to cut the target tissue after firing the staples, the surgeon activates the knife advancement trigger **200** in the above-described manner to drive the knife bar **172** through the target tissue to the end of the end effector. Thereafter, the surgeon may release the knife advancement trigger **200** to enable the firing return spring **202** to cause the firing transmission to return the knife bar **172** to the starting (un-actuated) position. Once the knife bar **172** has been returned to the starting position, the surgeon may open the end effector jaws **13**, **15** to release the implantable cartridge **30** within the patient and then withdraw the end effector **12** from the patient. Thus, such surgical instruments facilitate the use of small implantable staple cartridges that may be inserted through relatively smaller working channels and passages, while providing the surgeon with the option to fire the staples without cutting tissue or if desired to also cut tissue after the staples have been fired.

Various unique and novel embodiments of the present invention employ a compressible staple cartridge that supports staples in a substantially stationary position for forming contact by the anvil. In various embodiments, the anvil is driven into the unformed staples wherein, in at least one such embodiment, the degree of staple formation attained is dependent upon how far the anvil is driven into the staples. Such an arrangement provides the surgeon with the ability to adjust the amount of forming or firing pressure applied to the staples and thereby alter the final formed height of the staples. In other various embodiments of the present invention, surgical stapling arrangements can employ staple driving elements which can lift the staples toward the anvil. Such embodiments are described in greater detail further below.

In various embodiments, with regard to the embodiments described in detail above, the amount of firing motion that is applied to the movable anvil is dependent upon the degree of actuation of the firing trigger. For example, if the surgeon desires to attain only partially formed staples, then the firing trigger is only partially depressed inward towards the pistol grip **107**. To attain more staple formation, the surgeon simply compresses the firing trigger further which results in the anvil being further driven into forming contact with the staples. As used herein, the term "forming contact" means that the staple forming surface or staple forming pockets have contacted the ends of the staple legs and have started to form or bend the legs over into a formed position. The degree of staple formation refers to how far the staple legs have been folded over and ultimately relates to the forming height of the staple as referenced above. Those of ordinary skill in the art will further understand that, because the anvil **20** moves in a substantially parallel relationship with respect to the staple cartridge as the firing motions are applied thereto, the staples are formed substantially simultaneously with substantially the same formed heights.

FIGS. **2** and **3** illustrate an alternative end effector **12"** that is similar to the end effector **12'** described above, except with the following differences that are configured to accommodate a knife bar **172'**. The knife bar **172'** is coupled to or protrudes from a knife rod **180** and is otherwise operated in the above described manner with respect to the knife bar **172**. However, in this embodiment, the knife bar **172'** is long enough to traverse the entire length of the end effector **12"** and therefore, a separate distal knife member is not employed in the end effector **12"**. The knife bar **172'** has an upper transverse member **173'** and a lower transverse member **175'** formed thereon. The upper transverse member **173'** is oriented to slidably transverse a corresponding elongated slot **250** in anvil **20"** and the lower transverse member **175'** is oriented to traverse an elongated slot **252** in the elongated channel **14"** of the end effector **12"**. A disengagement slot (not shown) is also provided in the anvil **20"** such that when the knife bar **172'** has been driven to an ending position within end effector **12"**, the upper transverse member **173'** drops through the corresponding slot to enable the anvil **20"** to move to the open position to disengage the stapled and cut tissue. The anvil **20"** may be otherwise identical to anvil **20** described above and the elongated channel **14"** may be otherwise identical to elongated channel **14** described above.

In these embodiments, the anvil **20"** is biased to a fully open position (FIG. **2**) by a spring or other opening arrangement (not shown). The anvil **20"** is moved between the open and fully clamped positions by the axial travel of the firing adapter **150** in the manner described above. Once the firing adapter **150** has been advanced to the fully clamped position (FIG. **3**), the surgeon may then advance the knife bar **172"** distally in the manner described above. If the surgeon desires to use the end effector as a grasping device to manipulate tissue, the firing adapter may be moved proximally to allow the anvil **20"** to move away from the elongated channel **14"** as represented in FIG. **4** in broken lines. In this embodiment, as the knife bar **172"** moves distally, the upper transverse member **173'** and the lower transverse member **175'** draw the anvil **20"** and elongated channel **14"** together to achieve the desired staple formation as the knife bar **172"** is advanced distally through the end effector **12"**. See FIG. **5**. Thus, in this embodiment, staple formation occurs simultaneously with tissue cutting, but the staples themselves may be sequentially formed as the knife bar **172"** is driven distally.

The unique and novel features of the various surgical staple cartridges and the surgical instruments of the present invention enable the staples in those cartridges to be arranged in one or more linear or non-linear lines. A plurality of such staple lines may be provided on each side of an elongated slot that is centrally disposed within the staple cartridge for receiving the tissue cutting member therethrough. In one arrangement, for example, the staples in one line may be substantially parallel with the staples in adjacent line(s) of staples, but offset therefrom. In still other embodiments, one or more lines of staples may be non-linear in nature. That is, the base of at least one staple in a line of staples may extend along an axis that is substantially transverse to the bases of other staples in the same staple line. For example, the lines of staples on each side of the elongated slot may have a zigzag appearance.

In various embodiments, a staple cartridge can comprise a cartridge body and a plurality of staples stored within the cartridge body. In use, the staple cartridge can be introduced into a surgical site and positioned on a side of the tissue being treated. In addition, a staple-forming anvil can be positioned on the opposite side of the tissue. In various embodiments, the anvil can be carried by a first jaw and the staple cartridge can be carried by a second jaw, wherein the first jaw and/or the second jaw can be moved toward the other. Once the staple cartridge and the anvil have been positioned relative to the tissue, the staples can be ejected from the staple cartridge body such that the staples can pierce the tissue and contact the staple-forming anvil. Once the staples have been deployed from the staple cartridge body, the staple cartridge body can then be removed from the surgical site. In various embodiments disclosed herein, a staple cartridge, or at least a portion of a staple cartridge, can be implanted with the staples. In at least one such embodiment, as described in greater detail further below, a staple cartridge can comprise a cartridge body which can be compressed, crushed, and/or collapsed by the anvil when the anvil is moved from an open position into a closed position. When the cartridge body is compressed, crushed, and/or collapsed, the staples positioned within the cartridge body can be deformed by the anvil. Alternatively, the jaw supporting the staple cartridge can be moved toward the anvil into a closed position. In either event, in various embodiments, the staples can be deformed while they are at least partially positioned within the cartridge body. In certain embodiments, the staples may not be ejected from the staple cartridge while, in some embodiments, the staples can be ejected from the staple cartridge along with a portion of the cartridge body.

Referring now to FIGS. **6**A-**6**D, a compressible staple cartridge, such as staple cartridge **1000**, for example, can comprise a compressible, implantable cartridge body **1010** and, in addition, a plurality of staples **1020** positioned in the compressible cartridge body **1010**, although only one staple **1020** is depicted in FIGS. **6**A-**6**D. FIG. **6**A illustrates the staple cartridge **1000** supported by a staple cartridge support, or staple cartridge channel, **1030**, wherein the staple cartridge **1000** is illustrated in an uncompressed condition. In such an uncompressed condition, the anvil **1040** may or may not be in contact with the tissue T. In use, the anvil **1040** can be moved from an open position into contact with the tissue T as illustrated in FIG. **6**B and position the tissue T against the cartridge body **1010**. Even though the anvil **1040** can position the tissue T against a tissue-contacting surface **1019** of staple cartridge body **1010**, referring again to FIG. **6**B, the staple cartridge body **1010** may be subjected to little, if any, compressive force or pressure at such point and the staples **1020** may remain in an unformed, or unfired, condition. As illustrated in FIGS. **6**A and **6**B, the staple cartridge body **1010** can comprise one or more layers and the staple legs **1021** of staples **1020** can extend upwardly through these layers. In various embodiments, the cartridge body **1010** can comprise a first layer **1011**, a second layer **1012**, a third layer **1013**, wherein the second layer **1012** can be positioned intermediate the first layer **1011** and the third layer **1013**, and a fourth layer **1014**, wherein the third layer **1013** can be positioned intermediate the second layer **1012** and the fourth layer **1014**. In at least one embodiment, the bases **1022** of the staples **1020** can be positioned within cavities **1015** in the fourth layer **1014** and the staple legs **1021** can extend upwardly from the bases **1022** and through the fourth layer **1014**, the third layer **1013**, and the second layer **1012**, for example. In various embodiments, each deformable leg **1021** can comprise a tip, such as sharp tip **1023**, for example, which can be positioned in the second layer **1012**, for example, when the staple cartridge **1000** is in an uncompressed condition. In at least one such embodiment, the tips **1023** may not extend into and/or through the first layer **1011**, wherein, in at least one embodiment, the tips **1023** may not protrude through the tissue-contacting surface **1019** when the staple cartridge **1000** is in an uncompressed condition. In certain other embodiments, the sharp tips **1023** may be positioned in the third layer **1013**, and/or any other suitable layer, when the staple cartridge is in an uncompressed condition. In various alternative embodiments, a cartridge body of a staple cartridge may have any suitable number of layers such as less than four layers or more than four layers, for example.

In various embodiments, as described in greater detail below, the first layer **1011** can be comprised of a buttress material and/or plastic material, such as polydioxanone (PDS) and/or polyglycolic acid (PGA), for example, and the second layer **1012** can be comprised of a bioabsorbable foam material and/or a compressible haemostatic material, such as oxidized regenerated cellulose (ORC), for example. In various embodiments, one or more of the first layer **1011**, the second layer **1012**, the third layer **1013**, and the fourth layer **1014** may hold the staples **1020** within the staple cartridge body **1010** and, in addition, maintain the staples **1020** in alignment with one another. In various embodiments, the third layer **1013** can be comprised of a buttress material, or a fairly incompressible or inelastic material, which can be configured to hold the staple legs **1021** of the staples **1020** in position relative to one another. Furthermore, the second layer **1012** and the fourth layer **1014**, which are positioned on opposite sides of the third layer **1013**, can stabilize, or reduce the movement of, the staples **1020** even though the second layer **1012** and the fourth layer **1014** can be comprised of a compressible foam or elastic material. In certain embodiments, the staple tips **1023** of the staple legs **1021** can be at least partially embedded in the first layer **1011**. In at least one such embodiment, the first layer **1011** and the third layer **1013** can be configured to co-operatively and firmly hold the staple legs **1021** in position. In at least one embodiment, the first layer **1011** and the third layer **1013** can each be comprised of a sheet of bioabsorbable plastic, such as polyglycolic acid (PGA) which is marketed under the trade name Vicryl, polylactic acid (PLA or PLLA), polydioxanone (PDS), polyhydroxyalkanoate (PHA), poliglecaprone **25** (PGCL) which is marketed under the trade name Monocryl, polycaprolactone (PCL), and/or a composite of PGA, PLA, PDS, PHA, PGCL and/or PCL, for example, and the second layer **1012** and the fourth layer **1014** can each be comprised of at least one haemostatic material or agent.

Although the first layer **1011** can be compressible, the second layer **1012** can be substantially more compressible than the first layer **1011**. For example, the second layer **1012** can be about twice as compressible, about three times as compressible, about four times as compressible, about five times as compressible, and/or about ten times as compressible, for example, as the first layer **1011**. Stated another way, the second layer **1012** may compress about two times, about three times, about four times, about five times, and/or about ten times as much as first layer **1011**, for a given force. In certain embodiments, the second layer **1012** can be between about twice as compressible and about ten times as compressible, for example, as the first layer **1011**. In at least one embodiment, the second layer **1012** can comprise a plurality of air voids defined therein, wherein the amount and/or size of the air voids in the second layer **1012** can be controlled in order to provide a desired compressibility of the second layer **1012**. Similar to the above, although the third layer **1013** can be compressible, the fourth layer **1014** can be substantially more compressible than the third layer **1013**. For example, the fourth layer **1014** can be about twice as compressible, about three times as compressible, about four times as compressible, about five times as compressible, and/or about ten times as compressible, for example, as the third layer **1013**. Stated another way, the fourth layer **1014** may compress about two times, about three times, about four times, about five times, and/or about ten times as much as third layer **1013**, for a given force. In certain embodiments, the fourth layer **1014** can be between about twice as compressible and about ten times as compressible, for example, as the third layer **1013**. In at least one embodiment, the fourth layer **1014** can comprise a plurality of air voids defined therein, wherein the amount and/or size of the air voids in the fourth layer **1014** can be controlled in order to provide a desired compressibility of the fourth layer **1014**. In various circumstances, the compressibility of a cartridge body, or cartridge body layer, can be expressed in terms of a compression rate, i.e., a distance in which a layer is compressed for a given amount of force. For example, a layer having a high compression rate will compress a larger distance for a given amount of compressive force applied to the layer as compared to a layer having a lower compression rate. This being said, the second layer **1012** can have a higher compression rate than the first layer **1011** and, similarly, the fourth layer **1014** can have a higher compression rate than the third layer **1013**. In various embodiments, the second layer **1012** and the fourth layer **1014** can be comprised of the same material and can comprise the same compression rate. In various embodiments, the second layer **1012** and the fourth layer **1014** can be comprised of materials having different compression rates. Similarly, the first layer **1011** and the third layer **1013** can be comprised of the same material and can comprise the same compression rate. In certain embodiments, the first layer **1011** and the third layer **1013** can be comprised of materials having different compression rates.

As the anvil **1040** is moved toward its closed position, the anvil **1040** can contact tissue T and apply a compressive force to the tissue T and the staple cartridge **1000**, as illustrated in FIG. **6**C. In such circumstances, the anvil **1040** can push the top surface, or tissue-contacting surface **1019**, of the cartridge body **1010** downwardly toward the staple cartridge support **1030**. In various embodiments, the staple cartridge support **1030** can comprise a cartridge support surface **1031** which can be configured to support the staple cartridge **1000** as the staple cartridge **1000** is compressed between the cartridge support surface **1031** and the tissue-contacting surface **1041** of anvil **1040**. Owing to the pressure applied by the anvil **1040**, the cartridge body **1010** can be compressed and the anvil **1040** can come into contact with the staples **1020**. More particularly, in various embodiments, the compression of the cartridge body **1010** and the downward movement of the tissue-contacting surface **1019** can cause the tips **1023** of the staple legs **1021** to pierce the first layer **1011** of cartridge body **1010**, pierce the tissue T, and enter into forming pockets **1042** in the anvil **1040**. As the cartridge body **1010** is further compressed by the anvil **1040**, the tips **1023** can contact the walls defining the forming pockets **1042** and, as a result, the legs **1021** can be deformed or curled inwardly, for example, as illustrated in FIG. **6**C. As the staple legs **1021** are being deformed, as also illustrated in FIG. **6**C, the bases **1022** of the staples **1020** can be in contact with or supported by the staple cartridge support **1030**. In various embodiments, as described in greater detail below, the staple cartridge support **1030** can comprise a plurality of support features, such as staple support grooves, slots, or troughs **1032**, for example, which can be configured to support the staples **1020**, or at least the bases **1022** of the staples **1020**, as the staples **1020** are being deformed. As also illustrated in FIG. **6**C, the cavities **1015** in the fourth layer **1014** can collapse as a result of the compressive force applied to the staple cartridge body **1010**. In addition to the cavities **1015**, the staple cartridge body **1010** can further comprise one or more voids, such as voids **1016**, for example, which may or may not comprise a portion of a staple positioned therein, that can be configured to allow the cartridge body **1010** to collapse. In various embodiments, the cavities **1015** and/or the voids **1016** can be configured to collapse such that the walls defining the cavities and/or walls deflect downwardly and contact the cartridge support surface **1031** and/or contact a layer of the cartridge body **1010** positioned underneath the cavities and/or voids.

Upon comparing FIG. **6**B and FIG. **6**C, it is evident that the second layer **1012** and the fourth layer **1014** have been substantially compressed by the compressive pressure applied by the anvil **1040**. It may also be noted that the first layer **1011** and the third layer **1013** have been compressed as well. As the anvil **1040** is moved into its closed position, the anvil **1040** may continue to further compress the cartridge body **1010** by pushing the tissue-contacting surface **1019** downwardly toward the staple cartridge support **1030**. As the cartridge body **1010** is further compressed, the anvil **1040** can deform the staples **1020** into their completely-formed shape as illustrated in FIG. **6**D. Referring to FIG. **6**D, the legs **1021** of each staple **1020** can be deformed downwardly toward the base **1022** of each staple **1020** in order to capture at least a portion of the tissue T, the first layer **1011**, the second layer **1012**, the third layer **1013**, and the fourth layer **1014** between the deformable legs **1021** and the base **1022**. Upon comparing FIGS. **6**C and **6**D, it is further evident that the second layer **1012** and the fourth layer **1014** have been further substantially compressed by the compressive pressure applied by the anvil **1040**. It may also be noted upon comparing FIGS. **6**C and **6**D that the first layer **1011** and the third layer **1013** have been further compressed as well. After the staples **1020** have been completely, or at least sufficiently, formed, the anvil **1040** can be lifted away from the tissue T and the staple cartridge support **1030** can be moved away, and/or detached from, the staple cartridge **1000**. As depicted in FIG. **6**D, and as a result of the above, the cartridge body **1010** can be implanted with the staples **1020**. In various circumstances, the implanted cartridge body **1010** can support the tissue along the staple line. In some circumstances, a haemostatic agent, and/or any other suitable therapeutic medicament, contained within the implanted cartridge body **1010** can treat the tissue over time. A haemostatic agent, as mentioned above, can reduce the bleeding of the stapled and/or incised tissue while a bonding agent or tissue adhesive can provide strength to the tissue over time. The implanted cartridge body **1010** can be comprised of materials such as ORC (oxidized regenerated cellulose), extracellular proteins such as collagen, polyglycolic acid (PGA) which is marketed under the trade name Vicryl, polylactic acid (PLA or PLLA), polydioxanone (PDS), polyhydroxyalkanoate (PHA), poliglecaprone **25** (PGCL) which is marketed under the trade name Monocryl, polycaprolactone (PCL), and/or a composite of PGA, PLA, PDS, PHA, PGCL and/or PCL, for example. In certain circumstances, the cartridge body **1010** can comprise an antibiotic and/or anti-microbial material, such as colloidal silver and/or triclosan, for example, which can reduce the possibility of infection in the surgical site.

In various embodiments, the layers of the cartridge body **1010** can be connected to one another. In at least one embodiment, the second layer **1012** can be adhered to the first layer **1011**, the third layer **1013** can be adhered to the second layer **1012**, and the fourth layer **1014** can be adhered to the third layer **1013** utilizing at least one adhesive, such as fibrin and/or protein hydrogel, for example. In certain embodiments, although not illustrated, the layers of the cartridge body **1010** can be connected together by interlocking mechanical features. In at least one such embodiment, the first layer **1011** and the second layer **1012** can each comprise corresponding interlocking features, such as a tongue and groove arrangement and/or a dovetail joint arrangement, for example. Similarly, the second layer **1012** and the third layer **1013** can each comprise corresponding interlocking features while the third layer **1013** and the fourth layer **1014** can each comprise corresponding interlocking features. In certain embodiments, although not illustrated, the staple cartridge **1000** can comprise one or more rivets, for example, which can extend through one or more layers of the cartridge body **1010**. In at least one such embodiment, each rivet can comprise a first end, or head, positioned adjacent to the first layer **1011** and a second head positioned adjacent to the fourth layer **1014** which can be either assembled to or formed by a second end of the rivet. Owing to the compressible nature of the cartridge body **1010**, in at least one embodiment, the rivets can compress the cartridge body **1010** such that the heads of the rivets can be recessed relative to the tissue-contacting surface **1019** and/or the bottom surface **1018** of the cartridge body **1010**, for example. In at least one such embodiment, the rivets can be comprised of a bioabsorbable material, such as polyglycolic acid (PGA) which is marketed under the trade name Vicryl, polylactic acid (PLA or PLLA), polydioxanone (PDS), polyhydroxyalkanoate (PHA), poliglecaprone **25** (PGCL) which is marketed under the trade name Monocryl, polycaprolactone (PCL), and/or a composite of PGA, PLA, PDS, PHA, PGCL and/or PCL, for example. In certain embodiments, the layers of the cartridge body **1010** may not be connected to one another other than by the staples **1020** contained therein. In at least one such embodiment, the frictional engagement between the staple legs **1021** and the cartridge body **1010**, for example, can hold the layers of the cartridge body **1010** together and, once the staples have been formed, the layers can be captured within the staples **1020**. In certain embodiments, at least a portion of the staple legs **1021** can comprise a roughened surface or rough coating which can increase the friction forces between the staples **1020** and the cartridge body **1010**.

As described above, a surgical instrument can comprise a first jaw including the staple cartridge support **1030** and a second jaw including the anvil **1040**. In various embodiments, as described in greater detail further below, the staple cartridge **1000** can comprise one or more retention features which can be configured to engage the staple cartridge support **1030** and, as a result, releasably retain the staple cartridge **1000** to the staple cartridge support **1030**. In certain embodiments, the staple cartridge **1000** can be adhered to the staple cartridge support **1030** by at least one adhesive, such as fibrin and/or protein hydrogel, for example. In use, in at least one circumstance, especially in laparoscopic and/or endoscopic surgery, the second jaw can be moved into a closed position opposite the first jaw, for example, such that the first and second jaws can be inserted through a trocar into a surgical site. In at least one such embodiment, the trocar can define an approximately 5 mm aperture, or cannula, through which the first and second jaws can be inserted. In certain embodiments, the second jaw can be moved into a partially-closed position intermediate the open position and the closed position which can allow the first and second jaws to be inserted through the trocar without deforming the staples **1020** contained in the staple cartridge body **1010**. In at least one such embodiment, the anvil **1040** may not apply a compressive force to the staple cartridge body **1010** when the second jaw is in its partially-closed intermediate position while, in certain other embodiments, the anvil **1040** can compress the staple cartridge body **1010** when the second jaw is in its partially-closed intermediate position. Even though the anvil **1040** can compress the staple cartridge body **1010** when it is in such an intermediate position, the anvil **1040** may not sufficiently compress the staple cartridge body **1010** such that the anvil **1040** comes into contact with the staples **1020** and/or such that the staples

1020 are deformed by the anvil **1040**. Once the first and second jaws have been inserted through the trocar into the surgical site, the second jaw can be opened once again and the anvil **1040** and the staple cartridge **1000** can be positioned relative to the targeted tissue as described above.

In various embodiments, referring now to FIGS. **7A-7D**, an end effector of a surgical stapler can comprise an implantable staple cartridge **1100** positioned intermediate an anvil **1140** and a staple cartridge support **1130**. Similar to the above, the anvil **1140** can comprise a tissue-contacting surface **1141**, the staple cartridge **1100** can comprise a tissue-contacting surface **1119**, and the staple cartridge support **1130** can comprise a support surface **1131** which can be configured to support the staple cartridge **1100**. Referring to FIG. **7A**, the anvil **1140** can be utilized to position the tissue T against the tissue contacting surface **1119** of staple cartridge **1100** without deforming the staple cartridge **1100** and, when the anvil **1140** is in such a position, the tissue-contacting surface **1141** can be positioned a distance **1101***a* away from the staple cartridge support surface **1131** and the tissue-contacting surface **1119** can be positioned a distance **1102***a* away from the staple cartridge support surface **1131**. Thereafter, as the anvil **1140** is moved toward the staple cartridge support **1130**, referring now to FIG. **7B**, the anvil **1140** can push the top surface, or tissue-contacting surface **1119**, of staple cartridge **1100** downwardly and compress the first layer **1111** and the second layer **1112** of cartridge body **1110**. As the layers **1111** and **1112** are compressed, referring again to FIG. **7B**, the second layer **1112** can be crushed and the legs **1121** of staples **1120** can pierce the first layer **1111** and enter into the tissue T. In at least one such embodiment, the staples **1120** can be at least partially positioned within staple cavities, or voids, **1115** in the second layer **1112** and, when the second layer **1112** is compressed, the staple cavities **1115** can collapse and, as a result, allow the second layer **1112** to collapse around the staples **1120**. In various embodiments, the second layer **1112** can comprise cover portions **1116** which can extend over the staple cavities **1115** and enclose, or at least partially enclose, the staple cavities **1115**. FIG. **7B** illustrates the cover portions **1116** being crushed downwardly into the staple cavities **1115**. In certain embodiments, the second layer **1112** can comprise one or more weakened portions which can facilitate the collapse of the second layer **1112**. In various embodiments, such weakened portions can comprise score marks, perforations, and/or thin cross-sections, for example, which can facilitate a controlled collapse of the cartridge body **1110**. In at least one embodiment, the first layer **1111** can comprise one or more weakened portions which can facilitate the penetration of the staple legs **1121** through the first layer **1111**. In various embodiments, such weakened portions can comprise score marks, perforations, and/or thin cross-sections, for example, which can be aligned, or at least substantially aligned, with the staple legs **1121**.

When the anvil **1140** is in a partially closed, unfired position, referring again to FIG. **7A**, the anvil **1140** can be positioned a distance **1101***a* away from the cartridge support surface **1131** such that a gap is defined therebetween. This gap can be filled by the staple cartridge **1100**, having a staple cartridge height **1102***a*, and the tissue T. As the anvil **1140** is moved downwardly to compress the staple cartridge **1100**, referring again to FIG. **7B**, the distance between the tissue contacting surface **1141** and the cartridge support surface **1131** can be defined by a distance **1101***b* which is shorter than the distance **1101***a*. In various circumstances, the gap between the tissue-contacting surface **1141** of anvil **1140** and the cartridge support surface **1131**, defined by distance **1101***b*, may be larger than the original, undeformed staple cartridge height **1102***a*. As the anvil **1140** is moved closer to the cartridge support surface **1131**, referring now to FIG. **7C**, the second layer **1112** can continue to collapse and the distance between the staple legs **1121** and the forming pockets **1142** can decrease. Similarly, the distance between the tissue-contacting surface **1141** and the cartridge support surface **1131** can decrease to a distance **1101***c* which, in various embodiments, may be greater than, equal to, or less than the original, undeformed cartridge height **1102***a*. Referring now to FIG. **7D**, the anvil **1140** can be moved into a final, fired position in which the staples **1120** have been fully formed, or at least formed to a desired height. In such a position, the tissue-contacting surface **1141** of anvil **1140** can be a distance **1101***d* away from the cartridge support surface **1131**, wherein the distance **1101***d* can be shorter than the original, undeformed cartridge height **1102***a*. As also illustrated in FIG. **7D**, the staple cavities **1115** may be fully, or at least substantially, collapsed and the staples **1120** may be completely, or at least substantially, surrounded by the collapsed second layer **1112**. In various circumstances, the anvil **1140** can be thereafter moved away from the staple cartridge **1100**. Once the anvil **1140** has been disengaged from the staple cartridge **1100**, the cartridge body **1110** can at least partially re-expand in various locations, i.e., locations intermediate adjacent staples **1120**, for example. In at least one embodiment, the crushed cartridge body **1110** may not resiliently re-expand. In various embodiments, the formed staples **1120** and, in addition, the cartridge body **1110** positioned intermediate adjacent staples **1120** may apply pressure, or compressive forces, to the tissue T which may provide various therapeutic benefits.

As discussed above, referring again to the embodiment illustrated in FIG. **7A**, each staple **1120** can comprise staple legs **1121** extending therefrom. Although staples **1120** are depicted as comprising two staple legs **1121**, various staples can be utilized which can comprise one staple leg or, alternatively, more than two staple legs, such as three staple legs or four staple legs, for example. As illustrated in FIG. **7A**, each staple leg **1121** can be embedded in the second layer **1112** of the cartridge body **1110** such that the staples **1120** are secured within the second layer **1112**. In various embodiments, the staples **1120** can be inserted into the staple cavities **1115** in cartridge body **1110** such that the tips **1123** of the staple legs **1121** enter into the cavities **1115** before the bases **1122**. After the tips **1123** have been inserted into the cavities **1115**, in various embodiments, the tips **1123** can be pressed into the cover portions **1116** and incise the second layer **1112**. In various embodiments, the staples **1120** can be seated to a sufficient depth within the second layer **1112** such that the staples **1120** do not move, or at least substantially move, relative to the second layer **1112**. In certain embodiments, the staples **1120** can be seated to a sufficient depth within the second layer **1112** such that the bases **1122** are positioned or embedded within the staple cavities **1115**. In various other embodiments, the bases **1122** may not be positioned or embedded within the second layer **1112**. In certain embodiments, referring again to FIG. **7A**, the bases **1122** may extend below the bottom surface **1118** of the cartridge body **1110**. In certain embodiments, the bases **1122** can rest on, or can be directly positioned against, the cartridge support surface **1130**. In various embodiments, the cartridge support surface **1130** can comprise support features extending therefrom and/or defined therein wherein, in at least one such embodiment, the bases **1122** of the staples **1120** may be positioned within and supported by one or more support grooves, slots, or troughs, **1132**, for example, in the staple cartridge support **1130**, as described in greater detail further below.

In various embodiments, referring now to FIGS. **8** and **9**, a staple cartridge, such as staple cartridge **1200**, for example, can comprise a compressible, implantable cartridge body **1210** comprising an outer layer **1211** and an inner layer **1212**. Similar to the above, the staple cartridge **1200** can comprise a plurality of staples **1220** positioned within the cartridge body **1210**. In various embodiments, each staple **1220** can comprise a base **1222** and one or more staple legs **1221** extending therefrom. In at least one such embodiment, the staple legs **1221** can be inserted into the inner layer **1212** and seated to a depth in which the bases **1222** of the staples **1220** abut and/or are positioned adjacent to the bottom surface **1218** of the inner layer **1212**, for example. In the embodiment depicted in FIGS. **8** and **9**, the inner layer **1212** does not comprise staple cavities configured to receive a portion of the staples **1220** while, in other embodiments, the inner layer **1212** can comprise such staple cavities. In various embodiments, further to the above, the inner layer **1212** can be comprised of a compressible material, such as bioabsorbable foam and/or oxidized regenerated cellulose (ORC), for example, which can be configured to allow the cartridge body **1210** to collapse when a compressive load is applied thereto. In various embodiments, the inner layer **1212** can be comprised of a lyophilized foam comprising polylactic acid (PLA) and/or polyglycolic acid (PGA), for example. The ORC may be commercially available under the trade name Surgical and can comprise a loose woven fabric (like a surgical sponge), loose fibers (like a cotton ball), and/or a foam. In at least one embodiment, the inner layer **1212** can be comprised of a material including medicaments, such as freeze-dried thrombin and/or fibrin, for example, contained therein and/or coated thereon which can be water-activated and/or activated by fluids within the patient's body, for example. In at least one such embodiment, the freeze-dried thrombin and/or fibrin can be held on a Vicryl (PGA) matrix, for example. In certain circumstances, however, the activatable medicaments can be unintentionally activated when the staple cartridge **1200** is inserted into a surgical site within the patient, for example. In various embodiments, referring again to FIGS. **8** and **9**, the outer layer **1211** can be comprised of a water impermeable, or at least substantially water impermeable, material such that liquids do not come into contact with, or at least substantially contact, the inner layer **1212** until after the cartridge body **1210** has been compressed and the staple legs have penetrated the outer layer **1211** and/or after the outer layer **1211** has been incised in some fashion. In various embodiments, the outer layer **1211** can be comprised of a buttress material and/or plastic material, such as polydioxanone (PDS) and/or polyglycolic acid (PGA), for example. In certain embodiments, the outer layer **1211** can comprise a wrap which surrounds the inner layer **1212** and the staples **1220**. More particularly, in at least one embodiment, the staples **1220** can be inserted into the inner layer **1212** and the outer layer **1211** can be wrapped around the sub-assembly comprising the inner layer **1212** and the staples **1220** and then sealed.

In various embodiments described herein, the staples of a staple cartridge can be fully formed by an anvil when the anvil is moved into a closed position. In various other embodiments, referring now to FIGS. **10-13**, the staples of a staple cartridge, such as staple cartridge **4100**, for example, can be deformed by an anvil when the anvil is moved into a closed position and, in addition, by a staple driver system which moves the staples toward the closed anvil. The staple cartridge **4100** can comprise a compressible cartridge body **4110** which can be comprised of a foam material, for example, and a plurality of staples **4120** at least partially positioned within the compressible cartridge body **4110**. In various embodiments, the staple driver system can comprise a driver holder **4160**, a plurality of staple drivers **4162** positioned within the driver holder **4160**, and a staple cartridge pan **4180** which can be configured to retain the staple drivers **4162** in the driver holder **4160**. In at least one such embodiment, the staple drivers **4162** can be positioned within one or more slots **4163** in the driver holder **4160** wherein the sidewalls of the slots **4163** can assist in guiding the staple drivers **4162** upwardly toward the anvil. In various embodiments, the staples **4120** can be supported within the slots **4163** by the staple drivers **4162** wherein, in at least one embodiment, the staples **4120** can be entirely positioned in the slots **4163** when the staples **4120** and the staple drivers **4162** are in their unfired positions. In certain other embodiments, at least a portion of the staples **4120** can extend upwardly through the open ends **4161** of slots **4163** when the staples **4120** and staple drivers **4162** are in their unfired positions. In at least one such embodiment, referring primarily now to FIG. **11**, the bases of the staples **4120** can be positioned within the driver holder **4160** and the tips of the staples **4120** can be embedded within the compressible cartridge body **4110**. In certain embodiments, approximately one-third of the height of the staples **4120** can be positioned within the driver holder **4160** and approximately two-thirds of the height of the staples **4120** can be positioned within the cartridge body **4110**. In at least one embodiment, referring to FIG. **10**A, the staple cartridge **4100** can further comprise a water impermeable wrap or membrane **4111** surrounding the cartridge body **4110** and the driver holder **4160**, for example.

In use, the staple cartridge **4100** can be positioned within a staple cartridge channel, for example, and the anvil can be moved toward the staple cartridge **4100** into a closed position. In various embodiments, the anvil can contact and compress the compressible cartridge body **4110** when the anvil is moved into its closed position. In certain embodiments, the anvil may not contact the staples **4120** when the anvil is in its closed position. In certain other embodiments, the anvil may contact the legs of the staples **4120** and at least partially deform the staples **4120** when the anvil is moved into its closed position. In either event, the staple cartridge **4100** can further comprise one or more sleds **4170** which can be advanced longitudinally within the staple cartridge **4100** such that the sleds **4170** can sequentially engage the staple drivers **4162** and move the staple drivers **4162** and the staples **4120** toward the anvil. In various embodiments, the sleds **4170** can slide between the staple cartridge pan **4180** and the staple drivers **4162**. In embodiments where the closure of the anvil has started the forming process of the staples **4120**, the upward movement of the staples **4120** toward the anvil can complete the forming process and deform the staples **4120** to their fully formed, or at least desired, height. In embodiments where the closure of the anvil has not deformed the staples **4120**, the upward movement of the staples **4120** toward the anvil can initiate and complete the forming process and deform the staples **4120** to their fully formed, or at least desired, height. In various embodiments, the sleds **4170** can be advanced from a proximal end of the staple cartridge **4100** to a distal end of the staple cartridge **4100** such that the staples **4120** positioned in the proximal end of the staple cartridge **4100** are fully formed before the staples **4120** positioned in the distal end of the staple cartridge **4100** are fully formed. In at least one embodiment, referring to FIG. **12**, the sleds **4170** can each comprise at least one angled or inclined surface **4711** which can be configured to slide underneath the staple drivers **4162** and lift the staple drivers **4162** as illustrated in FIG. **13**.

In various embodiments, further to the above, the staples **4120** can be formed in order to capture at least a portion of the tissue T and at least a portion of the compressible cartridge body **4110** of the staple cartridge **4100** therein. After the staples **4120** have been formed, the anvil and the staple cartridge channel **4130** of the surgical stapler can be moved away from the implanted staple cartridge **4100**. In various circumstances, the cartridge pan **4180** can be fixedly engaged with the staple cartridge channel **4130** wherein, as a result, the cartridge pan **4180** can become detached from the compressible cartridge body **4110** as the staple cartridge channel **4130** is pulled away from the implanted cartridge body **4110**. In various embodiments, referring again to FIG. **10**, the cartridge pan **4180** can comprise opposing side walls **4181** between which the cartridge body **4110** can be removably positioned. In at least one such embodiment, the compressible cartridge body **4110** can be compressed between the side walls **4181** such that the cartridge body **4110** can be removably retained therebetween during use and releasably disengaged from the cartridge pan **4180** as the cartridge pan **4180** is pulled away. In at least one such embodiment, the driver holder **4160** can be connected to the cartridge pan **4180** such that the driver holder **4160**, the drivers **4162**, and/or the sleds **4170** can remain in the cartridge pan **4180** when the cartridge pan **4180** is removed from the surgical site. In certain other embodiments, the drivers **4162** can be ejected from the driver holder **4160** and left within the surgical site. In at least one such embodiment, the drivers **4162** can be comprised of a bioabsorbable material, such as polyglycolic acid (PGA) which is marketed under the trade name Vicryl, polylactic acid (PLA or PLLA), polydioxanone (PDS), polyhydroxyalkanoate (PHA), poliglecaprone **25** (PGCL) which is marketed under the trade name Monocryl, polycaprolactone (PCL), and/or a composite of PGA, PLA, PDS, PHA, PGCL and/or PCL, for example. In various embodiments, the drivers **4162** can be attached to the staples **4120** such that the drivers **4162** are deployed with the staples **4120**. In at least one such embodiment, each driver **4162** can comprise a trough configured to receive the bases of the staples **4120**, for example, wherein, in at least one embodiment, the troughs can be configured to receive the staple bases in a press-fit and/or snap-fit manner.

In certain embodiments, further to the above, the driver holder **4160** and/or the sleds **4170** can be ejected from the cartridge pan **4180**. In at least one such embodiment, the sleds **4170** can slide between the cartridge pan **4180** and the driver holder **4160** such that, as the sleds **4170** are advanced in order to drive the staple drivers **4162** and staples **4120** upwardly, the sleds **4170** can move the driver holder **4160** upwardly out of the cartridge pan **4180** as well. In at least one such embodiment, the driver holder **4160** and/or the sleds **4170** can be comprised of a bioabsorbable material, such as polyglycolic acid (PGA) which is marketed under the trade name Vicryl, polylactic acid (PLA or PLLA), polydioxanone (PDS), polyhydroxyalkanoate (PHA), poliglecaprone **25** (PGCL) which is marketed under the trade name Monocryl, polycaprolactone (PCL), and/or a composite of PGA, PLA, PDS, PHA, PGCL and/or PCL, for example. In various embodiments, the sleds **4170** can be integrally formed and/or attached to a drive bar, or cutting member, which pushes the sleds **4170** through the staple cartridge **4100**. In such embodiments, the sleds **4170** may not be ejected from the cartridge pan **4180** and may remain with the surgical stapler while, in other embodiments in which the sleds **4170** are not attached to the drive bar, the sleds **4170** may be left in the surgical site. In any event, further to the above, the compressibility of the cartridge body **4110** can allow thicker staple cartridges to be used within an end effector of a surgical stapler as the cartridge body **4110** can compress, or shrink, when the anvil of the stapler is closed. In certain embodiments, as a result of the staples being at least partially deformed upon the closure of the anvil, taller staples, such as staples having an approximately 0.18" staple height, for example, could be used, wherein approximately 0.12" of the staple height can be positioned within the compressible layer **4110** and wherein the compressible layer **4110** can have an uncompressed height of approximately 0.14", for example.

In many embodiments described herein, a staple cartridge can comprise a plurality of staples therein. In various embodiments, such staples can be comprised of a metal wire deformed into a substantially U-shaped configuration having two staple legs. Other embodiments are envisioned in which staples can comprise different configurations such as two or more wires that have been joined together having three or more staple legs. In various embodiments, the wire, or wires, used to form the staples can comprise a round, or at least substantially round, cross-section. In at least one embodiment, the staple wires can comprise any other suitable cross-section, such as square and/or rectangular cross-sections, for example. In certain embodiments, the staples can be comprised of plastic wires. In at least one embodiment, the staples can be comprised of plastic-coated metal wires. In various embodiments, a cartridge can comprise any suitable type of fastener in addition to or in lieu of staples. In at least one such embodiment, such a fastener can comprise pivotable arms which are folded when engaged by an anvil. In certain embodiments, two-part fasteners could be utilized. In at least one such embodiment, a staple cartridge can comprise a plurality of first fastener portions and an anvil can comprise a plurality of second fastener portions which are connected to the first fastener portions when the anvil is compressed against the staple cartridge. In certain embodiments, as described above, a sled or driver can be advanced within a staple cartridge in order to complete the forming process of the staples. In certain embodiments, a sled or driver can be advanced within an anvil in order to move one or more forming members downwardly into engagement with the opposing staple cartridge and the staples, or fasteners, positioned therein.

In various embodiments described herein, a staple cartridge can comprise four rows of staples stored therein. In at least one embodiment, the four staple rows can be arranged in two inner staple rows and two outer staple rows. In at least one such embodiment, an inner staple row and an outer staple row can be positioned on a first side of a cutting member, or knife, slot within the staple cartridge and, similarly, an inner staple row and an outer staple row can be positioned on a second side of the cutting member, or knife, slot. In certain embodiments, a staple cartridge may not comprise a cutting member slot; however, such a staple cartridge may comprise a designated portion configured to be incised by a cutting member in lieu of a staple cartridge slot. In various embodiments, the inner staple rows can be arranged within the staple cartridge such that they are equally, or at least substantially equally, spaced from the cutting member slot. Similarly, the outer staple rows can be arranged within the staple cartridge such that they are equally, or at least substantially equally, spaced from the cutting member slot. In various embodiments, a staple cartridge can comprise more than or less than four rows of staples stored within a staple cartridge. In at least one embodiment, a staple cartridge can comprise six rows of staples. In at least one such embodiment, the staple cartridge can comprise three rows of staples on a first side of a cutting member slot and three rows of staples on a second side of the cutting member slot. In certain embodiments, a staple cartridge may comprise an odd number of staple rows. For example, a staple cartridge may comprise two rows of staples on a first side of a cutting member slot and three rows of staples on a second side of the cutting member slot. In various embodiments, the staple rows can comprise staples having the same, or at least substantially the same, unformed staple height. In certain other embodiments, one or more of the staple rows can comprise staples having a different unformed staple height than the other staples. In at least one such embodiment, the staples on a first side of a cutting member slot may have a first unformed height and the staples on a second side of a cutting member slot may have a second unformed height which is different than the first height, for example.

In various embodiments, as described above, a staple cartridge can comprise a cartridge body including a plurality of staple cavities defined therein. The cartridge body can comprise a deck and a top deck surface wherein each staple cavity can define an opening in the deck surface. As also described above, a staple can be positioned within each staple cavity such that the staples are stored within the cartridge body until they are ejected therefrom. Prior to being ejected from the cartridge body, in various embodiments, the staples can be contained with the cartridge body such that the staples do not protrude above the deck surface. As the staples are positioned below the deck surface, in such embodiments, the possibility of the staples becoming damaged and/or prematurely contacting the targeted tissue can be reduced. In various circumstances, the staples can be moved between an unfired position in which they do not protrude from the cartridge body and a fired position in which they have emerged from the cartridge body and can contact an anvil positioned opposite the staple cartridge. In various embodiments, the anvil, and/or the forming pockets defined within the anvil, can be positioned a predetermined distance above the deck surface such that, as the staples are being deployed from the cartridge body, the staples are deformed to a predetermined formed height. In some circumstances, the thickness of the tissue captured between the anvil and the staple cartridge may vary and, as a result, thicker tissue may be captured within certain staples while thinner tissue may be captured within certain other staples. In either event, the clamping pressure, or force, applied to the tissue by the staples may vary from staple to staple or vary between a staple on one end of a staple row and a staple on the other end of the staple row, for example. In certain circumstances, the gap between the anvil and the staple cartridge deck can be controlled such that the staples apply a certain minimum clamping pressure within each staple. In some such circumstances, however, significant variation of the clamping pressure within different staples may still exist. Surgical stapling instruments are disclosed in U.S. Pat. No. 7,380,696, which issued on Jun. 3, 2008, the entire disclosure of which is incorporated by reference herein. An illustrative multi-stroke handle for the surgical stapling and severing instrument is described in greater detail in the co-pending and co-owned U.S. patent application entitled SURGICAL STAPLING INSTRUMENT INCORPORATING A MULTISTROKE FIRING POSITION INDICATOR AND RETRACTION MECHANISM, Ser. No. 10/674,026, now U.S. Pat. No. 7,364,061, the disclosure of which is hereby incorporated by reference in its entirety. Other applications consistent with the present invention may incorporate a single firing stroke, such as described in co-pending and commonly owned U.S. patent application SURGICAL STAPLING INSTRUMENT HAVING SEPARATE DISTINCT CLOSING AND FIRING SYSTEMS, Ser. No. 10/441,632, now U.S. Pat. No. 7,000,818, the disclosure of which is hereby incorporated by reference in its entirety.

In various embodiments described herein, a staple cartridge can comprise means for compensating for the thickness of the tissue captured within the staples deployed from the staple cartridge. In various embodiments, referring to FIG. **14**, a staple cartridge, such as staple cartridge **10000**, for example, can include a rigid first portion, such as support portion **10010**, for example, and a compressible second portion, such as tissue thickness compensator **10020**, for example. In at least one embodiment, referring primarily to FIG. **16**, the support portion **10010** can comprise a cartridge body, a top deck surface **10011**, and a plurality of staple cavities **10012** wherein, similar to the above, each staple cavity **10012** can define an opening in the deck surface **10011**. A staple **10030**, for example, can be removably positioned in each staple cavity **10012**. In at least one such embodiment, each staple **10030** can comprise a base **10031** and one or more legs **10032** extending from the base **10031**. Prior to the staples **10030** being deployed, as also described in greater detail below, the bases **10031** of the staples **10030** can be supported by staple drivers positioned within the support portion **10010** and, concurrently, the legs **10032** of the staples **10030** can be at least partially contained within the staple cavities **10012**. In various embodiments, the staples **10030** can be deployed between an unfired position and a fired position such that the legs **10032** move through the tissue thickness compensator **10020**, penetrate through a top surface of the tissue thickness compensator **10020**, penetrate the tissue T, and contact an anvil positioned opposite the staple cartridge **10000**. As the legs **10032** are deformed against the anvil, the legs **10032** of each staple **10030** can capture a portion of the tissue thickness compensator **10020** and a portion of the tissue T within each staple **10030** and apply a compressive force to the tissue. Further to the above, the legs **10032** of each staple **10030** can be deformed downwardly toward the base **10031** of the staple to form a staple entrapment area **10039** in which the tissue T and the tissue thickness compensator **10020** can be captured. In various circumstances, the staple entrapment area **10039** can be defined between the inner surfaces of the deformed legs **10032** and the inner surface of the base **10031**. The size of the entrapment area for a staple can depend on several factors such as the length of the legs, the diameter of the legs, the width of the base, and/or the extent in which the legs are deformed, for example.

In previous embodiments, a surgeon was often required to select the appropriate staples having the appropriate staple height for the tissue being stapled. For example, a surgeon could select tall staples for use with thick tissue and short staples for use with thin tissue. In some circumstances, however, the tissue being stapled did not have a consistent thickness and, thus, some staples were unable to achieve the desired fired configuration. For example, FIG. **48** illustrates a tall staple used in thin tissue. Referring now to FIG. **49**, when a tissue thickness compensator, such as tissue thickness compensator **10020**, for example, is used with thin tissue, for example, the larger staple may be formed to a desired fired configuration.

Owing to the compressibility of the tissue thickness compensator, the tissue thickness compensator can compensate for the thickness of the tissue captured within each staple. More particularly, referring now to FIGS. **43** and **44**, a tissue thickness compensator, such as tissue thickness compensator **10020**, for example, can consume larger and/or smaller portions of the staple entrapment area **10039** of each staple **10030** depending on the thickness and/or type of tissue contained within the staple entrapment area **10039**. For example, if thinner tissue T is captured within a staple **10030**, the tissue thickness compensator **10020** can consume a larger portion of the staple entrapment area **10039** as compared to circumstances where thicker tissue T is captured within the staple **10030**. Correspondingly, if thicker tissue T is captured within a staple **10030**, the tissue thickness compensator **10020** can consume a smaller portion of the staple entrapment area **10039** as compared to the circumstances where thinner tissue T is captured within the staple **10030**. In this way, the tissue thickness compensator can compensate for thinner tissue and/or thicker tissue and assure that a compressive pressure is applied to the tissue irrespective, or at least substantially irrespective, of the tissue thickness captured within the staples. In addition to the above, the tissue thickness compensator **10020** can compensate for different types, or compressibilities, of tissues captured within different staples **10030**. Referring now to FIG. **44**, the tissue thickness compensator **10020** can apply a compressive force to vascular tissue T which can include vessels V and, as a result, restrict the flow of blood through the less compressible vessels V while still applying a desired compressive pressure to the surrounding tissue T. In various circumstances, further to the above, the tissue thickness compensator **10020** can also compensate for malformed staples. Referring to FIG. **45**, the malformation of various staples **10030** can result in larger staple entrapment areas **10039** being defined within such staples. Owing to the resiliency of the tissue thickness compensator **10020**, referring now to FIG. **46**, the tissue thickness compensator **10020** positioned within malformed staples **10030** may still apply a sufficient compressive pressure to the tissue T even though the staple entrapment areas **10039** defined within such malformed staples **10030** may be enlarged. In various circumstances, the tissue thickness compensator **10020** located intermediate adjacent staples **10030** can be biased against the tissue T by properly-formed staples **10030** surrounding a malformed staple **10030** and, as a result, apply a compressive pressure to the tissue surrounding and/or captured within the malformed staple **10030**, for example. In various circumstances, a tissue thickness compensator can compensate for different tissue densities which can arise due to calcifications, fibrous areas, and/or tissue that has been previously stapled or treated, for example.

In various embodiments, a fixed, or unchangeable, tissue gap can be defined between the support portion and the anvil and, as a result, the staples may be deformed to a predetermined height regardless of the thickness of the tissue captured within the staples. When a tissue thickness compensator is used with these embodiments, the tissue thickness compensator can adapt to the tissue captured between the anvil and the support portion staple cartridge and, owing to the resiliency of the tissue thickness compensator, the tissue thickness compensator can apply an additional compressive pressure to the tissue. Referring now to FIGS. **50-55**, a staple **10030** has been formed to a predefined height H. With regard to FIG. **50**, a tissue thickness compensator has not been utilized and the tissue T consumes the entirety of the staple entrapment area **10039**. With regard to FIG. **57**, a portion of a tissue thickness compensator **10020** has been captured within the staple **10030**, compressed the tissue T, and consumed at least a portion of the staple entrapment area **10039**. Referring now to FIG. **52**, thin tissue T has been captured within the staple **10030**. In this embodiment, the compressed tissue T has a height of approximately $\frac{2}{9}$H and the compressed tissue thickness compensator **10020** has a height of approximately $\frac{7}{9}$H, for example. Referring now to FIG. **53**, tissue T having an intermediate thickness has been captured within the staple **10030**. In this embodiment, the compressed tissue T has a height of approximately $\frac{4}{9}$H and the compressed tissue thickness compensator **10020** has a height of approximately $\frac{5}{9}$H, for example. Referring now to FIG. **54**, tissue T having an intermediate thickness has been captured within the staple **10030**. In this embodiment, the compressed tissue T has a height of approximately $\frac{2}{3}$H and the compressed tissue thickness compensator **10020** has a height of approximately $\frac{1}{3}$H, for example. Referring now to FIG. **53**, thick tissue T has been captured within the staple **10030**. In this embodiment, the compressed tissue T has a height of approximately $\frac{8}{9}$H and the compressed tissue thickness compensator **10020** has a height of approximately $\frac{1}{9}$H, for example. In various circumstances, the tissue thickness compensator can comprise a compressed height which comprises approximately 10% of the staple entrapment height, approximately 20% of the staple entrapment height, approximately 30% of the staple entrapment height, approximately 40% of the staple entrapment height, approximately 50% of the staple entrapment height, approximately 60% of the staple entrapment height, approximately 70% of the staple entrapment height, approximately 80% of the staple entrapment height, and/or approximately 90% of the staple entrapment height, for example.

In various embodiments, the staples **10030** can comprise any suitable unformed height. In certain embodiments, the staples **10030** can comprise an unformed height between approximately 2 mm and approximately 4.8 mm, for example. The staples **10030** can comprise an unformed height of approximately 2.0 mm, approximately 2.5 mm, approximately 3.0 mm, approximately 3.4 mm, approximately 3.5 mm, approximately 3.8 mm, approximately 4.0 mm, approximately 4.1 mm, and/or approximately 4.8 mm, for example. In various embodiments, the height H to which the staples can be deformed can be dictated by the distance between the deck surface **10011** of the support portion **10010** and the opposing anvil. In at least one embodiment, the distance between the deck surface **10011** and the tissue-contacting surface of the anvil can be approximately 0.097", for example. The height H can also be dictated by the depth of the forming pockets defined within the anvil. In at least one embodiment, the forming pockets can have a depth measured from the tissue-contacting surface, for example. In various embodiments, as described in greater detail below, the staple cartridge **10000** can further comprise staple drivers which can lift the staples **10030** toward the anvil and, in at least one embodiment, lift, or "overdrive", the staples above the deck surface **10011**. In such embodiments, the height H to which the staples **10030** are formed can also be dictated by the distance in which the staples **10030** are overdriven. In at least one such embodiment, the staples **10030** can be overdriven by approximately 0.028", for example, and can result in the staples **10030** being formed to a height of approximately 0.189", for example. In various embodiments, the staples **10030** can be formed to a height of approximately 0.8 mm, approximately 1.0 mm, approximately 1.5 mm, approximately 1.8 mm, approximately 2.0 mm, and/or approximately 2.25 mm, for example. In certain embodiments, the staples can be formed to a height between approximately 2.25 mm and approximately 3.0 mm, for example. Further to the above, the height of the staple entrapment area of a staple can be determined by the formed height of the staple and the width, or diameter, of the wire comprising the staple. In various embodiments, the height of the staple entrapment area **10039** of a staple **10030** can comprise the formed height H of the staple less two diameter widths of the wire. In certain embodiments, the staple wire can comprise a diameter of approximately 0.0089", for example. In various embodiments, the staple wire can comprise a diameter between approximately 0.0069" and approximately 0.0119", for example. In at least one exemplary embodiment, the formed height H of a staple **10030** can be approximately 0.189" and the staple wire diameter can be approximately 0.0089" resulting in a staple entrapment height of approximately 0.171", for example.

In various embodiments, further to the above, the tissue thickness compensator can comprise an uncompressed, or pre-deployed, height and can be configured to deform to one of a plurality of compressed heights. In certain embodiments, the tissue thickness compensator can comprise an uncompressed height of approximately 0.125", for example. In various embodiments, the tissue thickness compensator can comprise an uncompressed height of greater than or equal to approximately 0.080", for example. In at least one embodiment, the tissue thickness compensator can comprise an uncompressed, or pre-deployed, height which is greater than the unfired height of the staples. In at least one embodiment, the uncompressed, or pre-deployed, height of the tissue thickness compensator can be approximately 10% taller, approximately 20% taller, approximately 30% taller, approximately 40% taller, approximately 50% taller, approximately 60% taller, approximately 70% taller, approximately 80% taller, approximately 90% taller, and/or approximately 100% taller than the unfired height of the staples, for example. In at least one embodiment, the uncompressed, or pre-deployed, height of the tissue thickness compensator can be up to approximately 100% taller than the unfired height of the staples, for example. In certain embodiments, the uncompressed, or pre-deployed, height of the tissue thickness compensator can be over 100% taller than the unfired height of the staples, for example. In at least one embodiment, the tissue thickness compensator can comprise an uncompressed height which is equal to the unfired height of the staples. In at least one embodiment, the tissue thickness compensator can comprise an uncompressed height which is less than the unfired height of the staples. In at least one embodiment, the uncompressed, or pre-deployed, height of the thickness compensator can be approximately 10% shorter, approximately 20% shorter, approximately 30% shorter, approximately 40% shorter, approximately 50% shorter, approximately 60% shorter, approximately 70% shorter, approximately 80% shorter, and/or approximately 90% shorter than the unfired height of the staples, for example. In various embodiments, the compressible second portion can comprise an uncompressed height which is taller than an uncompressed height of the tissue T being stapled. In certain embodiments, the tissue thickness compensator can comprise an uncompressed height which is equal to an uncompressed height of the tissue T being stapled. In various embodiments, the tissue thickness compensator can comprise an uncompressed height which is shorter than an uncompressed height of the tissue T being stapled.

As described above, a tissue thickness compensator can be compressed within a plurality of formed staples regardless of whether thick tissue or thin tissue is captured within the staples. In at least one exemplary embodiment, the staples within a staple line, or row, can be deformed such that the staple entrapment area of each staple comprises a height of approximately 2.0 mm, for example, wherein the tissue T and the tissue thickness compensator can be compressed within this height. In certain circumstances, the tissue T can comprise a compressed height of approximately 1.75 mm within the staple entrapment area while the tissue thickness compensator can comprise a compressed height of approximately 0.25 mm within the staple entrapment area, thereby totaling the approximately 2.0 mm staple entrapment area height, for example. In certain circumstances, the tissue T can comprise a compressed height of approximately 1.50 mm within the staple entrapment area while the tissue thickness compensator can comprise a compressed height of approximately 0.50 mm within the staple entrapment area, thereby totaling the approximately 2.0 mm staple entrapment area height, for example. In certain circumstances, the tissue T can comprise a compressed height of approximately 1.25 mm within the staple entrapment area while the tissue thickness compensator can comprise a compressed height of approximately 0.75 mm within the staple entrapment area, thereby totaling the approximately 2.0 mm staple entrapment area height, for example. In certain circumstances, the tissue T can comprise a compressed height of approximately 1.0 mm within the staple entrapment area while the tissue thickness compensator can comprise a compressed height of approximately 1.0 mm within the staple entrapment area, thereby totaling the approximately 2.0 mm staple entrapment area height, for example. In certain circumstances, the tissue T can comprise a compressed height of approximately 0.75 mm within the staple entrapment area while the tissue thickness compensator can comprise a compressed height of approximately 1.25 mm within the staple entrapment area, thereby totaling the approximately 2.0 mm staple entrapment area height, for example. In certain circumstances, the tissue T can comprise a compressed height of approximately 1.50 mm within the staple entrapment area while the tissue thickness compensator can comprise a compressed height of approximately 0.50 mm within the staple entrapment area, thereby totaling the approximately 2.0 mm staple entrapment area height, for example. In certain circumstances, the tissue T can comprise a compressed height of approximately 0.25 mm within the staple entrapment area while the tissue thickness compensator can comprise a compressed height of approximately 1.75 mm within the staple entrapment area, thereby totaling the approximately 2.0 mm staple entrapment area height, for example.

In various embodiments, further to the above, the tissue thickness compensator can comprise an uncompressed height which is less than the fired height of the staples. In certain embodiments, the tissue thickness compensator can comprise an uncompressed height which is equal to the fired height of the staples. In certain other embodiments, the tissue thickness compensator can comprise an uncompressed height which is taller than the fired height of the staples. In at least one such embodiment, the uncompressed height of a tissue thickness compensator can comprise a thickness which is approximately 110% of the formed staple height, approximately 120% of the formed staple height, approximately 130% of the formed staple height, approximately 140% of the formed staple height, approximately 150% of the formed staple height, approximately 160% of the formed staple height, approximately 170% of the formed staple height, approximately 180% of the formed staple height, approximately 190% of the formed staple height, and/or approximately 200% of the formed staple height, for example. In certain embodiments, the tissue thickness compensator can comprise an uncompressed height which is more than twice the fired height of the staples. In various embodiments, the tissue thickness compensator can comprise a compressed height which is from approximately 85% to approximately 150% of the formed staple height, for example. In various embodiments, as described above, the tissue thickness compensator can be compressed between an uncompressed thickness and a compressed thickness. In certain embodiments, the compressed thickness of a tissue thickness compensator can be approximately 10% of its uncompressed thickness, approximately 20% of its uncompressed thickness, approximately 30% of its uncompressed thickness, approximately 40% of its uncompressed thickness, approximately 50% of its uncompressed thickness, approximately 60% of its uncompressed thickness, approximately 70% of its uncompressed thickness, approximately 80% of its uncompressed thickness, and/or approximately 90% of its uncompressed thickness, for example. In various embodiments, the uncompressed thickness of the tissue thickness compensator can be approximately two times, approximately ten times, approximately fifty times, and/or approximately one hundred times thicker than its compressed thickness, for example. In at least one embodiment, the compressed thickness of the tissue thickness compensator can be between approximately 60% and approximately 99% of its uncompressed thickness. In at least one embodiment, the uncompressed thickness of the tissue thickness compensator can be at least 50% thicker than its compressed thickness. In at least one embodiment, the uncompressed thickness of the tissue thickness compensator can be up to one hundred times thicker than its compressed thickness. In various embodiments, the compressible second portion can be elastic, or at least partially elastic, and can bias the tissue T against the deformed legs of the staples. In at least one such embodiment, the compressible second portion can resiliently expand between the tissue T and the base of the staple in order to push the tissue T against the legs of the staple. In certain embodiments, discussed in further detail below, the tissue thickness compensator can be positioned intermediate the tissue T and the deformed staple legs. In various circumstances, as a result of the above, the tissue thickness compensator can be configured to consume any gaps within the staple entrapment area.

In various embodiments, the tissue thickness compensator may comprise materials characterized by one or more of the following properties: biocompatible, bioabsorbable, bioresorbable, biodurable, biodegradable, compressible, fluid absorbable, swellable, self-expandable, bioactive, medicament, pharmaceutically active, anti-adhesion, haemostatic, antibiotic, anti-microbial, anti-viral, nutritional, adhesive, permeable, hydrophilic and/or hydrophobic, for example. In various embodiments, a surgical instrument comprising an anvil and a staple cartridge may comprise a tissue thickness compensator associated with the anvil and/or staple cartridge comprising at least one of a haemostatic agent, such as fibrin and thrombin, an antibiotic, such as doxycpl, and medicament, such as matrix metalloproteinases (MMPs).

In various embodiments, the tissue thickness compensator may comprise synthetic and/or non-synthetic materials. The tissue thickness compensator may comprise a polymeric composition comprising one or more synthetic polymers and/or one or more non-synthetic polymers. The synthetic polymer may comprise a synthetic absorbable polymer and/or a synthetic non-absorbable polymer. In various embodiments, the polymeric composition may comprise a biocompatible foam, for example. The biocompatible foam may comprise a porous, open cell foam and/or a porous, closed cell foam, for example. The biocompatible foam may have a uniform pore morphology or may have a gradient pore morphology (i.e. small pores gradually increasing in size to large pores across the thickness of the foam in one direction). In various embodiments, the polymeric composition may comprise one or more of a porous scaffold, a porous matrix, a gel matrix, a hydrogel matrix, a solution matrix, a filamentous matrix, a tubular matrix, a composite matrix, a membranous matrix, a biostable polymer, and a biodegradable polymer, and combinations thereof. For example, the tissue thickness compensator may comprise a foam reinforced by a filamentous matrix or may comprise a foam having an additional hydrogel layer that expands in the presence of bodily fluids to further provide the compression on the tissue. In various embodiments, a tissue thickness compensator could also be comprised of a coating on a material and/or a second or third layer that expands in the presence of bodily fluids to further provide the compression on the tissue. Such a layer could be a hydrogel that could be a synthetic and/or naturally derived material and could be either biodurable and/or biodegradable, for example. In various embodiments, the tissue thickness compensator may comprise a microgel or a nanogel. The hydrogel may comprise carbohydrate-derived microgels and/or nanogels. In certain embodiments, a tissue thickness compensator may be reinforced with fibrous non-woven materials or fibrous mesh type elements, for example, that can provide additional flexibility, stiffness, and/or strength. In various embodiments, a tissue thickness compensator that has a porous morphology which exhibits a gradient structure such as, for example, small pores on one surface and larger pores on the other surface. Such morphology could be more optimal for tissue in-growth or haemostatic behavior. Further, the gradient could be also compositional with a varying bio-absorption profile. A short term absorption profile may be preferred to address hemostasis while a long term absorption profile may address better tissue healing without leakages.

Examples of non-synthetic materials include, but are not limited to, lyophilized polysaccharide, glycoprotein, bovine pericardium, collagen, gelatin, fibrin, fibrinogen, elastin, proteoglycan, keratin, albumin, hydroxyethyl cellulose, cellulose, oxidized cellulose, oxidized regenerated cellulose (ORC), hydroxypropyl cellulose, carboxyethyl cellulose, carboxymethylcellulose, chitan, chitosan, casein, alginate, and combinations thereof.

Examples of synthetic absorbable materials include, but are not limited to, poly(lactic acid) (PLA), poly(L-lactic acid) (PLLA), polycaprolactone (PCL), polyglycolic acid (PGA), poly(trimethylene carbonate) (TMC), polyethylene terephthalate (PET), polyhydroxyalkanoate (PHA), a copolymer of glycolide and ϵ-caprolactone (PGCL), a copolymer of glycolide and -trimethylene carbonate, poly(glycerol sebacate) (PGS), poly(dioxanone) (PDS), polyesters, poly(orthoesters), polyoxaesters, polyetheresters, polycarbonates, polyamide esters, polyanhydrides, polysaccharides, poly(ester-amides), tyrosine-based polyarylates, polyamines, tyrosine-based polyiminocarbonates, tyrosine-based polycarbonates, poly(D,L-lactide-urethane), poly(hydroxybutyrate), poly(B-hydroxybutyrate), poly(ϵ-caprolactone), polyethyleneglycol (PEG), poly[bis(carboxylatophenoxy)phosphazene]poly (amino acids), pseudo-poly(amino acids), absorbable polyurethanes, poly(phosphazine), polyphosphazenes, polyalkyleneoxides, polyacrylamides, polyhydroxyethylmethylacrylate, polyvinylpyrrolidone, polyvinyl alcohols, poly(caprolactone), polyacrylic acid, polyacetate, polypropylene, aliphatic polyesters, glycerols, copoly(ether-esters), polyalkylene oxalates, polyamides, poly(iminocarbonates), polyalkylene oxalates, and combinations thereof. In various embodiments, the polyester is may be selected from the group consisting of polylactides, polyglycolides, trimethylene carbonates, polydioxanones, polycaprolactones, polybutesters, and combinations thereof.

In various embodiments, the synthetic absorbable polymer may comprise one or more of 90/10 poly(glycolide-L-lactide) copolymer, commercially available from Ethicon, Inc. under the trade designation VICRYL (polyglactic 910), polyglycolide, commercially available from American Cyanamid Co. under the trade designation DEXON, polydioxanone, commercially available from Ethicon, Inc. under the trade designation PDS, poly(glycolide-trimethylene carbonate) random block copolymer, commercially available from American Cyanamid Co. under the trade designation MAXON, 75/25 poly(glycolide-ϵ-caprolactone-poliglecaprolactone 25) copolymer, commercially available from Ethicon under the trade designation MONOCRYL, for example.

Examples of synthetic non-absorbable materials include, but are not limited to, polyurethane, polypropylene (PP), polyethylene (PE), polycarbonate, polyamides, such as nylon, polyvinylchloride (PVC), polymethylmethacrylate (PMMA), polystyrene (PS), polyester, polyetheretherketone (PEEK), polytetrafluoroethylene (PTFE), polytrifluorochloroethylene (PTFCE), polyvinylfluoride (PVF), fluorinated ethylene propylene (FEP), polyacetal, polysulfone, silicons, and combinations thereof. The synthetic non-absorbable polymers may include, but are not limited to, foamed elastomers and porous elastomers, such as, for example, silicone, polyisoprene, and rubber. In various embodiments, the synthetic polymers may comprise expanded polytetrafluoroethylene (ePTFE), commercially available from W. L. Gore & Associates, Inc. under the trade designation GORE-TEX Soft Tissue Patch and co-polyetherester urethane foam commercially available from Polyganics under the trade designation NASOPORE.

In various embodiments, the polymeric composition may comprise from approximately 50% to approximately 90% by weight of the polymeric composition of PLLA and approximately 50% to approximately 10% by weight of the polymeric composition of PCL, for example. In at least one embodiment, the polymeric composition may comprise approximately 70% by weight of PLLA and approximately 30% by weight of PCL, for example. In various embodiments, the polymeric composition may comprise from approximately 55% to approximately 85% by weight of the polymeric composition of PGA and 15% to 45% by weight of the polymeric composition of PCL, for example. In at least one embodiment, the polymeric composition may comprise approximately 65% by weight of PGA and approximately 35% by weight of PCL, for example. In various embodiments, the polymeric composition may comprise from approximately 90% to approximately 95% by weight of the polymeric composition of PGA and approximately 5% to approximately 10% by weight of the polymeric composition of PLA, for example.

In various embodiments, the synthetic absorbable polymer may comprise a bioabsorbable, biocompatible elastomeric copolymer. Suitable bioabsorbable, biocompatible elastomeric copolymers include but are not limited to copolymers of ϵ-caprolactone and glycolide (preferably having a mole ratio of ϵ-caprolactone to glycolide of from about 30:70 to about 70:30, preferably 35:65 to about 65:35, and more preferably 45:55 to 35:65); elastomeric copolymers of ϵ-caprolactone and lactide, including L-lactide, D-lactide blends thereof or lactic acid copolymers (preferably having a mole ratio of ϵ-caprolactone to lactide of from about 35:65 to about 65:35 and more preferably 45:55 to 30:70) elastomeric copolymers of p-dioxanone (1,4-dioxan-2-one) and lactide including L-lactide, D-lactide and lactic acid (preferably having a mole ratio of p-dioxanone to lactide of from about 40:60 to about 60:40); elastomeric copolymers of ϵ-caprolactone and p-dioxanone (preferably having a mole ratio of ϵ-caprolactone to p-dioxanone of from about 30:70 to about 70:30); elastomeric copolymers of p-dioxanone and trimethylene carbonate (preferably having a mole ratio of p-dioxanone to trimethylene carbonate of from about 30:70 to about 70:30); elastomeric copolymers of trimethylene carbonate and glycolide (preferably having a mole ratio of trimethylene carbonate to glycolide of from about 30:70 to about 70:30); elastomeric copolymer of trimethylene carbonate and lactide including L-lactide, D-lactide, blends thereof or lactic acid copolymers (preferably having a mole ratio of trimethylene

carbonate to lactide of from about 30:70 to about 70:30) and blends thereof. In one embodiment, the elastomeric copolymer is a copolymer of glycolide and ϵ-caprolactone. In another embodiment, the elastomeric copolymer is a copolymer of lactide and ϵ-caprolactone.

The disclosures of U.S. Pat. No. 5,468,253, entitled ELASTOMERIC MEDICAL DEVICE, which issued on Nov. 21, 1995, and U.S. Pat. No. 6,325,810, entitled FOAM BUTTRESS FOR STAPLING APPARATUS, which issued on Dec. 4, 2001, are hereby incorporated by reference in their respective entireties.

In various embodiments, the tissue thickness compensator may comprise an emulsifier. Examples of emulsifiers may include, but are not limited to, water-soluble polymers, such as, polyvinyl alcohol (PVA), polyvinyl pyrrolidone (PVP), polyethylene glycol (PEG), polypropylene glycol (PPG), PLURONICS, TWEENS, polysaccharides and combinations thereof.

In various embodiments, the tissue thickness compensator may comprise a surfactant. Examples of surfactants may include, but are not limited to, polyacrylic acid, methalose, methyl cellulose, ethyl cellulose, propyl cellulose, hydroxy ethyl cellulose, carboxy methyl cellulose, polyoxyethylene cetyl ether, polyoxyethylene lauryl ether, polyoxyethylene octyl ether, polyoxyethylene octylphenyl ether, polyoxyethylene oleyl ether, polyoxyethylene sorbitan monolaurate, polyoxyethylene stearyl ether, polyoxyethylene nonylphenyl ether, dialkylphenoxy poly(ethyleneoxy)ethanol, and polyoxamers.

In various embodiments, the polymeric composition may comprise a pharmaceutically active agent. The polymeric composition may release a therapeutically effective amount of the pharmaceutically active agent. In various embodiments, the pharmaceutically active agent may be released as the polymeric composition is desorbed/absorbed. In various embodiments, the pharmaceutically active agent may be released into fluid, such as, for example, blood, passing over or through the polymeric composition. Examples of pharmaceutically active agents may include, but are not limited to, haemostatic agents and drugs, such as, for example, fibrin, thrombin, and oxidized regenerated cellulose (ORC); anti-inflammatory drugs, such as, for example, diclofenac, aspirin, naproxen, sulindac, and hydrocortisone; antibiotic and antimicrobial drug or agents, such as, for example, triclosan, ionic silver, ampicillin, gentamicin, polymyxin B, chloramphenicol; and anticancer agents, such as, for example, cisplatin, mitomycin, adriamycin.

In various embodiments, the polymeric composition may comprise a haemostatic material. The tissue thickness compensator may comprise haemostatic materials comprising poly(lactic acid), poly(glycolic acid), poly(hydroxybutyrate), poly(caprolactone), poly(dioxanone), polyalkyleneoxides, copoly(ether-esters), collagen, gelatin, thrombin, fibrin, fibrinogen, fibronectin, elastin, albumin, hemoglobin, ovalbumin, polysaccharides, hyaluronic acid, chondroitin sulfate, hydroxyethyl starch, hydroxyethyl cellulose, cellulose, oxidized cellulose, hydroxypropyl cellulose, carboxyethyl cellulose, carboxymethyl cellulose, chitan, chitosan, agarose, maltose, maltodextrin, alginate, clotting factors, methacrylate, polyurethanes, cyanoacrylates, platelet agonists, vasoconstrictors, alum, calcium, RGD peptides, proteins, protamine sulfate, ϵ-amino caproic acid, ferric sulfate, ferric subsulfates, ferric chloride, zinc, zinc chloride, aluminum chloride, aluminum sulfates, aluminum acetates, permanganates, tannins, bone wax, polyethylene glycols, fucans and combinations thereof. The tissue thickness compensator may be characterized by haemostatic properties.

The polymeric composition of a tissue thickness compensator may be characterized by percent porosity, pore size, and/or hardness, for example. In various embodiments, the polymeric composition may have a percent porosity from approximately 30% by volume to approximately 99% by volume, for example. In certain embodiments, the polymeric composition may have a percent porosity from approximately 60% by volume to approximately 98% by volume, for example. In various embodiments, the polymeric composition may have a percent porosity from approximately 85% by volume to approximately 97% by volume, for example. In at least one embodiment, the polymeric composition may comprise approximately 70% by weight of PLLA and approximately 30% by weight of PCL, for example, and can comprise approximately 90% porosity by volume, for example. In at least one such embodiment, as a result, the polymeric composition would comprise approximately 10% copolymer by volume. In at least one embodiment, the polymeric composition may comprise approximately 65% by weight of PGA and approximately 35% by weight of PCL, for example, and can have a percent porosity from approximately 93% by volume to approximately 95% by volume, for example. In various embodiments, the polymeric composition may comprise greater than 85% porosity by volume. The polymeric composition may have a pore size from approximately 5 micrometers to approximately 2000 micrometers, for example. In various embodiments, the polymeric composition may have a pore size between approximately 10 micrometers to approximately 100 micrometers, for example. In at least one such embodiment, the polymeric composition can comprise a copolymer of PGA and PCL, for example. In certain embodiments, the polymeric composition may have a pore size between approximately 100 micrometers to approximately 1000 micrometers, for example. In at least one such embodiment, the polymeric composition can comprise a copolymer of PLLA and PCL, for example.

According to certain aspects, the hardness of a polymeric composition may be expressed in terms of the Shore Hardness, which can defined as the resistance to permanent indentation of a material as determined with a durometer, such as a Shore Durometer. In order to assess the durometer value for a given material, a pressure is applied to the material with a durometer indenter foot in accordance with ASTM procedure D2240-00, entitled, "Standard Test Method for Rubber Property-Durometer Hardness", the entirety of which is incorporated herein by reference. The durometer indenter foot may be applied to the material for a sufficient period of time, such as 15 seconds, for example, wherein a reading is then taken from the appropriate scale. Depending on the type of scale being used, a reading of 0 can be obtained when the indenter foot completely penetrates the material, and a reading of 100 can be obtained when no penetration into the material occurs. This reading is dimensionless. In various embodiments, the durometer may be determined in accordance with any suitable scale, such as Type A and/or Type OO scales, for example, in accordance with ASTM D2240-00. In various embodiments, the polymeric composition of a tissue thickness compensator may have a Shore A hardness value from approximately 4 A to approximately 16 A, for example, which is approximately 45 OO to approximately 65 OO on the Shore OO range. In at least one such embodiment, the polymeric composition can comprise a PLLA/PCL copolymer or a PGA/PCL copolymer, for example. In various embodiments, the polymeric composition of a tissue thickness compensator may have a Shore A Hardness value of less than 15 A. In various embodiments, the polymeric composition of a tissue thickness compensator may have a Shore A Hardness value of less than 10 A. In various embodiments, the polymeric composition of a tissue thickness compensator may have a Shore A Hardness value of less than 5 A. In certain embodiments, the polymeric material may have a Shore OO composition value from approximately 35 OO to approximately 75 OO, for example.

In various embodiments, the polymeric composition may have at least two of the above-identified properties. In various embodiments, the polymeric composition may have at least three of the above-identified properties. The polymeric composition may have a porosity from 85% to 97% by volume, a pore size from 5 micrometers to 2000 micrometers, and a Shore A hardness value from 4 A to 16 A and Shore OO hardness value from 45 OO to 65 OO, for example. In at least one embodiment, the polymeric composition may comprise 70% by weight of the polymeric composition of PLLA and 30% by weight of the polymeric composition of PCL having a porosity of 90% by volume, a pore size from 100 micrometers to 1000 micrometers, and a Shore A hardness value from 4 A to 16 A and Shore OO hardness value from 45 OO to 65 OO, for example. In at least one embodiment, the polymeric composition may comprise 65% by weight of the polymeric composition of PGA and 35% by weight of the polymeric composition of PCL having a porosity from 93% to 95% by volume, a pore size from 10 micrometers to 100 micrometers, and a Shore A hardness value from 4 A to 16 A and Shore OO hardness value from 45 OO to 65 OO, for example.

In various embodiments, the tissue thickness compensator may comprise a material that expands. As discussed above, the tissue thickness compensator may comprise a compressed material that expands when uncompressed or deployed, for example. In various embodiments, the tissue thickness compensator may comprise a self-expanding material formed in situ. In various embodiments, the tissue thickness compensator may comprise at least one precursor selected to spontaneously crosslink when contacted with at least one of other precursor(s), water, and/or bodily fluids. Referring to FIG. **205**, in various embodiments, a first precursor may contact one or more other precursors to form an expandable and/or swellable tissue thickness compensator. In various embodiments, the tissue thickness compensator may comprise a fluid-swellable composition, such as a water-swellable composition, for example. In various embodiments, the tissue thickness compensator may comprise a gel comprising water.

Referring to FIGS. **189**A and B, for example, a tissue thickness compensator **70000** may comprise at least one hydrogel precursor **70010** selected to form a hydrogel in situ and/or in vivo to expand the tissue thickness compensator **70000**. FIG. **189**A illustrates a tissue thickness compensator **70000** comprising an encapsulation comprising a first hydrogel precursor **70010**A and a second hydrogel precursor **70010**B prior to expansion. In certain embodiments, as shown in FIG. **189**A, the first hydrogel precursor **70010**A and second hydrogel precursor **70010**B may be physically separated from other in the same encapsulation. In certain embodiments, a first encapsulation may comprise the first hydrogel precursor **70010**A and a second encapsulation may comprise the second hydrogel precursor **70010**B. FIG. **189**B illustrates the expansion of the thickness tissue compensator **70000** when the hydrogel is formed in situ and/or in vivo. As shown in FIG. **189**B, the encapsulation may be ruptured, and the first hydrogel precursor **70010**A may contact the second hydrogel precursor **70010**B to form the hydrogel **70020**. In certain embodiments, the hydrogel may comprise an expandable material. In certain embodiments, the hydrogel may expand up to 72 hours, for example.

In various embodiments, the tissue thickness compensator may comprise a biodegradable foam having an encapsulation comprising dry hydrogel particles or granules embedded therein. Without wishing to be bound to any particular theory, the encapsulations in the foam may be formed by contacting an aqueous solution of a hydrogel precursor and an organic solution of biocompatible materials to form the foam. As shown in FIG. **206**, the aqueous solution and organic solution may form micelles. The aqueous solution and organic solution may be dried to encapsulate dry hydrogel particles or granules within the foam. For example, a hydrogel precursor, such as a hydrophilic polymer, may be dissolved in water to form a dispersion of micelles. The aqueous solution may contact an organic solution of dioxane comprising poly(glycolic acid) and polycaprolactone. The aqueous and organic solutions may be lyophilized to form a biodegradable foam having dry hydrogel particles or granules dispersed therein. Without wishing to be bound to any particular theory, it is believed that the micelles form the encapsulation having the dry hydrogel particles or granules dispersed within the foam structure. In certain embodiments, the encapsulation may be ruptured, and the dry hydrogel particles or granules may contact a fluid, such as a bodily fluid, and expand.

In various embodiments, the tissue thickness compensator may expand when contacted with an activator, such as a fluid, for example. Referring to FIG. **190**, for example, a tissue thickness compensator **70050** may comprise a swellable material, such as a hydrogel, that expands when contacted with a fluid **70055**, such as bodily fluids, saline, water and/or an activator, for example. Examples of bodily fluids may include, but are not limited to, blood, plasma, peritoneal fluid, cerebral spinal fluid, urine, lymph fluid, synovial fluid, vitreous fluid, saliva, gastrointestinal luminal contents, bile, and/or gas (e.g., CO_2). In certain embodiments, the tissue thickness compensator **70050** may expand when the tissue thickness compensator **70050** absorbs the fluid. In another example, the tissue thickness compensator **70050** may comprise a non-crosslinked hydrogel that expands when contacted with an activator **70055** comprising a cross-linking agent to form a crosslinked hydrogel. In various embodiments, the tissue thickness compensator may expand when contacted with an activator. In various embodiments, the tissue thickness compensator may expand or swell from contact up to 72 hours, such as from 24-72 hours, up to 24 hours, up to 48 hours, and up to 72 hours, for example, to provide continuously increasing pressure and/or compression to the tissue. As shown in FIG. **190**, the initial thickness of the tissue thickness compensator **70050** may be less than an expanded thickness after the fluid **70055** contacts the tissue thickness compensator **70050**.

Referring to FIGS. **187** and **188**, in various embodiments, a staple cartridge **70100** may comprise a tissue thickness compensator **70105** and a plurality of staples **70110** each comprising staple legs **70112**. As shown in FIG. **187**, tissue thickness compensator **70105** may have an initial thickness or compressed height that is less than the fired height of the staples **70110**. The tissue thickness compensator **70100** may be configured to expand in situ and/or in vivo when contacted with a fluid **70102**, such as bodily fluids, saline, and/or an activator for example, to push the tissue T against the legs **70112** of the staple **70110**. As shown in FIG. **188**, the tissue thickness compensator **70100** may expand and/or swell when contacted with a fluid **70102**. The tissue thickness compensator **70105** can compensate for the thickness of the tissue T captured within each staple **70110**. As shown in FIG. **188**, tissue thickness compensator **70105** may have an expanded thickness or an uncompressed height that is less than the fired height of the staples **70110**.

In various embodiments, as described above, the tissue thickness compensator may comprise an initial thickness and an expanded thickness. In certain embodiments, the initial thickness of a tissue thickness compensator can be approximately 0.001% of its expanded thickness, approximately 0.01% of its expanded thickness, approximately 0.1% of its expanded thickness, approximately 1% of its expanded thickness, approximately 10% of its expanded thickness, approximately 20% of its expanded thickness, approximately 30% of its expanded thickness, approximately 40% of its expanded thickness, approximately 50% of its expanded thickness, approximately 60% of its expanded thickness, approximately 70% of its expanded thickness, approximately 80% of its expanded thickness, and/or approximately 90% of its expanded thickness, for example. In various embodiments, the expanded thickness of the tissue thickness compensator can be approximately two times, approximately five times, approximately ten times, approximately fifty times, approximately one hundred times, approximately two hundred times, approximately three hundred times, approximately four hundred times, approximately five hundred times, approximately six hundred times, approximately seven hundred times, approximately eight hundred times, approximately nine hundred times, and/or approximately one thousand times thicker than its initial thickness, for example. In various embodiments, the initial thickness of the tissue thickness compensator can be up to 1% its expanded thickness, up to 5% its expanded thickness, up to 10% its expanded thickness, and up to 50% its expanded thickness. In various embodiments, the expanded thickness of the tissue thickness compensator can be at least 50% thicker than its initial thickness, at least 100% thicker than its initial thickness, at least 300% thicker than its initial thickness, and at least 500% thicker than its initial thickness. As described above, in various circumstances, as a result of the above, the tissue thickness compensator can be configured to consume any gaps within the staple entrapment area.

As discussed above, in various embodiments, the tissue thickness compensator may comprise a hydrogel. In various embodiments, the hydrogel may comprise homopolymer hydrogels, copolymer hydrogels, multipolymer hydrogels, interpenetrating polymer hydrogels, and combinations thereof. In various embodiments, the hydrogel may comprise microgels, nanogels, and combinations thereof. The hydrogel may generally comprise a hydrophilic polymer network capable of absorbing and/or retaining fluids. In various embodiments, the hydrogel may comprise a non-crosslinked hydrogel, a crosslinked hydrogel, and combinations thereof. The hydrogel may comprise chemical crosslinks, physical crosslinks, hydrophobic segments and/or water insoluble segments. The hydrogel may be chemically crosslinked by polymerization, small-molecule crosslinking, and/or polymer-polymer crosslinking. The hydrogel may be physically crosslinked by ionic interactions, hydrophobic interactions, hydrogen bonding interactions, sterocomplexation, and/or supramolecular chemistry. The hydrogel may be substantially insoluble due to the crosslinks, hydrophobic segments and/or water insoluble segments, but be expandable and/or swellable due to absorbing and/or retaining fluids. In certain embodiments, the precursor may crosslink with endogenous materials and/or tissues.

In various embodiments, the hydrogel may comprise an environmentally sensitive hydrogel (ESH). The ESH may comprise materials having fluid-swelling properties that relate to environmental conditions. The environmental conditions may include, but are not limited to, the physical conditions, biological conditions, and/or chemical conditions at the surgical site. In various embodiments, the hydrogel may swell or shrink in response to temperature, pH, electric fields, ionic strength, enzymatic and/or chemical reactions, electrical and/or magnetic stimuli, and other physiological and environmental variables, for example. In various embodiments, the ESH may comprise multifunctional acrylates, hydroxyethylmethacrylate (HEMA), elastomeric acrylates, and related monomers.

In various embodiments, the tissue thickness compensator comprising a hydrogel may comprise at least one of the non-synthetic materials and synthetic materials described above. The hydrogel may comprise a synthetic hydrogel and/or a non-synthetic hydrogel. In various embodiments, the tissue thickness compensator may comprise a plurality of layers. The plurality of the layers may comprise porous layers and/or non-porous layers. For example, the tissue thickness compensator may comprise a non-porous layer and a porous layer. In another example, the tissue thickness compensator may comprise a porous layer intermediate a first non-porous layer and a second non-porous layer. In another example, the tissue thickness compensator may comprise a non-porous layer intermediate a first porous layer and a second porous layer. The non-porous layers and porous layers may be positioned in any order relative to the surfaces of the staple cartridge and/or anvil.

Examples of the non-synthetic material may include, but are not limited to, albumin, alginate, carbohydrate, casein, cellulose, chitin, chitosan, collagen, blood, dextran, elastin, fibrin, fibrinogen, gelatin, heparin, hyaluronic acid, keratin, protein, serum, and starch. The cellulose may comprise hydroxyethyl cellulose, oxidized cellulose, oxidized regenerated cellulose (ORC), hydroxypropyl cellulose, carboxyethyl cellulose, carboxymethylcellulose, and combinations thereof. The collagen may comprise bovine pericardium. The carbohydrate may comprise a polysaccharide, such as lyophilized polysaccharide. The protein may comprise glycoprotein, proteoglycan, and combinations thereof.

Examples of the synthetic material may include, but are not limited to, poly(lactic acid), poly(glycolic acid), poly(hydroxybutyrate), poly(phosphazine), polyesters, polyethylene glycols, polyethylene oxide, polyethylene oxide-co-polypropylene oxide, co-polyethylene oxide, polyalkyleneoxides, polyacrylamides, polyhydroxyethylmethylacrylate, poly(vinylpyrrolidone), polyvinyl alcohols, poly(caprolactone), poly(dioxanone), polyacrylic acid, polyacetate, polypropylene, aliphatic polyesters, glycerols, poly(amino acids), copoly(ether-esters), polyalkylene oxalates, polyamides, poly(iminocarbonates), polyoxaesters, polyorthoesters, polyphosphazenes and combinations thereof. In certain embodiments, the above non-synthetic materials may be synthetically prepared, e.g., synthetic hyaluronic acid, utilizing conventional methods.

In various embodiments, the hydrogel may be made from one or more hydrogel precursors. The precursor may comprise a monomer and/or a macromer. The hydrogel precursor may comprise an electrophile functional group and/or a nucleophile electrophile functional group. In general, electrophiles may react with nucleophiles to form a bond. The term "functional group" as used herein refers to electrophilic or nucleophilic groups capable of reacting with each other to form a bond. Examples of electrophilic functional groups may include, but are not limited to, N-hydroxysuccinimides ("NHS"), sulfosuccinimides, carbonyldiimidazole, sulfonyl chloride, aryl halides, sulfosuccinimidyl esters, N-hydroxysuccinimidyl esters, succinimidyl esters such as succinimidyl succinates and/or succinimidyl propionates, isocyanates, thiocyanates, carbodiimides, benzotriazole carbonates, epoxides, aldehydes, maleimides, imidoesters, combinations thereof, and the like. In at least one embodiment, the electrophilic functional group may comprise a succinimidyl ester. Examples of nucleophile functional groups may include, but are not limited to, $—NH_2$, —SH, —OH, $—PH_2$, and —CO—NH—NH_2.

In various embodiments, the hydrogel may be formed from a single precursor or multiple precursors. In certain embodiments, the hydrogel may be formed from a first precursor and a second precursor. The first hydrogel precursor and second hydrogel precursor may form a hydrogel in situ and/or in vivo upon contact. The hydrogel precursor may generally refer to a polymer, functional group, macromolecule, small molecule, and/or crosslinker that can take part in a reaction to form a hydrogel. The precursor may comprise a homogeneous solution, heterogeneous, or phase separated solution in a suitable solvent, such as water or a buffer, for example. The buffer may have a pH from about 8 to about 12, such as, about 8.2 to about 9, for example. Examples of buffers may include, but are not limited to borate buffers. In certain embodiments, the precursor(s) may be in an emulsion. In various embodiments, a first precursor may react with a second precursor to form a hydrogel. In various embodiments, the first precursor may spontaneously crosslink when contacted with the second precursor. In various embodiments, a first set of electrophilic functional groups on a first precursor may react with a second set of nucleophilic functional groups on a second precursor. When the precursors are mixed in an environment that permits reaction (e.g., as relating to pH, temperature, and/or solvent), the functional groups may react with each other to form covalent bonds. The precursors may become crosslinked when at least some of the precursors react with more than one other precursor.

In various embodiments, the tissue thickness compensator may comprise at least one monomer selected from the group consisting of 3-sulfopropyl acrylate potassium salt ("KSPA"), sodium acrylate ("NaA"), N-(tris(hydroxylmethyl)methyl)acrylamide ("tris acryl"), and 2-acrylamido-2-methyl-1-propane sulfonic acid (AMPS). The tissue thickness compensator may comprise a copolymer comprising two or more monomers selected from the group consisting of KSPA, NaA, tris acryl, AMPS. The tissue thickness compensator may comprise homopolymers derived from KSPA, NaA, trisacryl and AMPS. The tissue thickness compensator may comprise hydrophilicity modifying monomers copolymerizable therewith. The hydrophilicity modifying monomers may comprise methylmethacrylate, butylacrylate, cyclohexylacrylate, styrene, styrene sulphonic acid.

In various embodiments, the tissue thickness compensator may comprise a crosslinker. The crosslinker may comprise a low molecular weight di- or polyvinylic crosslinking agent, such as ethyleneglycol diacrylate or dimethacrylate, di-, tri- or tetraethylen-glycol diacrylate or dimethacrylate, allyl (meth)acrylate, a C_2-C_8-alkylene diacrylate or dimethacrylate, divinyl ether, divinyl sulfone, di- and trivinylbenzene, trimethylolpropane triacrylate or trimethacrylate, pentaerythritol tetraacrylate or tetramethacrylate, bisphenol A diacrylate or dimethacrylate, methylene bisacrylamide or bismethacrylamide, ethylene bisacrylamide or ethylene bismethacrylamide, triallyl phthalate or diallyl phthalate. In at least one embodiment, the crosslinker may comprise N,N'-methylenebisacrylamide ("MBAA").

In various embodiments, the tissue thickness compensator may comprise at least one of acrylate and/or methacrylate functional hydrogels, biocompatible photoinitiator, alkyl-cyanoacrylates, isocyanate functional macromers, optionally comprising amine functional macromers, succinimidyl ester functional macromers, optionally comprising amine and/or sulfhydryl functional macromers, epoxy functional macromers, optionally comprising amine functional macromers, mixtures of proteins and/or polypeptides and aldehyde crosslinkers, Genipin, and water-soluble carbodiimides, anionic polysaccharides and polyvalent cations.

In various embodiments, the tissue thickness compensator may comprise unsaturated organic acid monomers, acrylic substituted alcohols, and/or acrylamides. In various embodiments, the tissue thickness compensator may comprise methacrylic acids, acrylic acids, glycerolacrylate, glycerolmethacryulate, 2-hydroxyethylmethacrylate, 2-hydroxyethylacrylate, 2-(dimethylaminoethyl) methacrylate, N-vinyl pyrrolidone, methacrylamide, and/or N,N-dimethylacrylamide poly(methacrylic acid).

In various embodiments, the tissue thickness compensator may comprise a reinforcement material. In various embodiments, the reinforcement material may comprise at least one of the non-synthetic materials and synthetic materials described above. In various embodiments, the reinforcement material may comprise collagen, gelatin, fibrin, fibrinogen, elastin, keratin, albumin, hydroxyethyl cellulose, cellulose, oxidized cellulose, hydroxypropyl cellulose, carboxyethyl cellulose, carboxymethylcellulose, chitan, chitosan, alginate, poly(lactic acid), poly(glycolic acid), poly(hydroxybutyrate), poly(phosphazine), polyesters, polyethylene glycols, polyalkyleneoxides, polyacrylamides, polyhydroxyethylmethylacrylate, polyvinylpyrrolidone, polyvinyl alcohols, poly(caprolactone), poly(dioxanone), polyacrylic acid, polyacetate, polycaprolactone, polypropylene, aliphatic polyesters, glycerols, poly(amino acids), copoly(ether-esters), polyalkylene oxalates, polyamides, poly(iminocarbonates), polyalkylene oxalates, polyoxaesters, polyorthoesters, polyphosphazenes and combinations thereof.

In various embodiments, the tissue thickness compensator may comprise a layer comprising the reinforcement material. In certain embodiments, a porous layer and/or a non-porous layer of a tissue thickness compensator may comprise the reinforcement material. For example, the porous layer may comprise the reinforcement material and the non-porous layer may not comprise the reinforcement material. In various embodiments, the reinforcement layer may comprise an inner layer intermediate a first non-porous layer and a second non-porous layer. In certain embodiments, the reinforcement layer may comprise an outer layer of the tissue thickness compensator. In certain embodiments, the reinforcement layer may comprise an exterior surface of the tissue thickness compensator.

In various embodiments, the reinforcement material may comprise meshes, monofilaments, multifilament braids, fibers, mats, felts, particles, and/or powders. In certain embodiments, the reinforcement material may be incorporated into a layer of the tissue thickness compensator. The reinforcement material may be incorporated into at least one of a non-porous layer and a porous layer. A mesh comprising the reinforcement material may be formed using conventional techniques, such as, for example, knitting, weaving, tatting, and/or knipling. In various embodiments, a plurality of reinforcement materials may be oriented in a random direction and/or a common direction. In certain embodiments, the common direction may be one of parallel to the staple line and perpendicular to the staple line, for example. For example, the monofilaments and/or multifilament braids may be oriented in a random direction and/or a common direction. The monofilaments and multifilament braids may be associated with the non-porous layer and/or the porous layer. In various embodiments, the tissue thickness compensator may comprise a plurality of reinforcement fibers oriented in a random direction within a non-porous layer. In various embodiments, the tissue thickness compensator may comprise a plurality of reinforcement fibers oriented in a common direction within a non-porous layer.

In various embodiments, referring to FIG. **199**, an anvil **70300** may comprise a tissue thickness compensator **70305** comprising a first non-porous layer **70307** and a second non-porous layer **70309** sealingly enclosing a reinforcement layer **70310**. In various embodiments, the reinforcement layer **70310** may comprise a hydrogel comprising ORC particles or fibers embedded therein, and the non-porous layers may comprise ORC. As shown in FIG. **199**, the tissue thickness compensator **70305** may be configured to conform to the contour of the anvil **70300**. The inner layer of the tissue thickness compensator **70305** may conform to the inner surface of the anvil **70300**, which includes the forming pockets **70301**.

The fibers may form a non-woven material, such as, for example, a mat and a felt. The fibers may have any suitable length, such as, for example from 0.1 mm to 100 mm and 0.4 mm to 50 mm. The reinforcement material may be ground to a powder. The powder may have a particle size from 10 micrometers to 1 cm, for example. The powder may be incorporated into the tissue thickness compensator.

In various embodiments, the tissue thickness compensator may be formed in situ. In various embodiments, the hydrogel may be formed in situ. The tissue thickness compensator may be formed in situ by covalent, ionic, and/or hydrophobic bonds. Physical (non-covalent) crosslinks may result from complexation, hydrogen bonding, desolvation, Van der Waals interactions, ionic bonding, and combinations thereof. Chemical (covalent) crosslinking may be accomplished by any of a number of mechanisms, including: free radical polymerization, condensation polymerization, anionic or cationic polymerization, step growth polymerization, electrophile-nucleophile reactions, and combinations thereof.

In various embodiments, in situ formation of the tissue thickness compensator may comprise reacting two or more precursors that are physically separated until contacted in situ and/or react to an environmental condition to react with each other to form the hydrogel. In situ polymerizable polymers may be prepared from precursor(s) that can be reacted to form a polymer at the surgical site. The tissue thickness compensator may be formed by crosslinking reactions of the precursor(s) in situ. In certain embodiments, the precursor may comprise an initiator capable of initiating a polymerization reaction for the formation of the in situ tissue thickness compensator. The tissue thickness compensator may comprise a precursor that can be activated at the time of application to create, in various embodiments, a crosslinked hydrogel. In situ formation of the tissue thickness compensator may comprise activating at least one precursor to form bonds to form the tissue thickness compensator. In various embodiments, activation may be achieved by changes in the physical conditions, biological conditions, and/or chemical conditions at the surgical site, including, but not limited to temperature, pH, electric fields, ionic strength, enzymatic and/or chemical reactions, electrical and/or magnetic stimuli, and other physiological and environmental variables. In various embodiments, the precursors may be contacted outside the body and introduced to the surgical site.

In various embodiments, the tissue thickness compensator may comprise one or more encapsulations, or cells, which can be configured to store at least one component therein. In certain embodiments, the encapsulation may be configured to store a hydrogel precursor therein. In certain embodiments, the encapsulation may be configured to store two components therein, for example. In certain embodiments, the encapsulation may be configured to store a first hydrogel precursor and a second hydrogel precursor therein. In certain embodiments, a first encapsulation may be configured to store a first hydrogel precursor therein and a second encapsulation may be configured to store a second hydrogel precursor therein. As described above, the encapsulations can be aligned, or at least substantially aligned, with the staple legs to puncture and/or otherwise rupture the encapsulations when the staple legs contact the encapsulation. In certain embodiments, the encapsulations may be compressed, crushed, collapsed, and/or otherwise ruptured when the staples are deployed. After the encapsulations have been ruptured, the component(s) stored therein can flow out of the encapsulation. The component stored therein may contact other components, layers of the tissue thickness compensator, and/or the tissue. In various embodiments, the other components may be flowing from the same or different encapsulations, provided in the layers of the tissue thickness compensator, and/or provided to the surgical site by the clinician. As a result of the above, the component(s) stored within the encapsulations can provide expansion and/or swelling of the tissue thickness compensator.

In various embodiments, the tissue thickness compensator may comprise a layer comprising the encapsulations. In various embodiments, the encapsulation may comprise a void, a pocket, a dome, a tube, and combinations thereof associated with the layer. In certain embodiments, the encapsulations may comprise voids in the layer. In at least one embodiment, the layer can comprise two layers that can be attached to one another wherein the encapsulations can be defined between the two layers. In certain embodiments, the encapsulations may comprise domes on the surface of the layer. For example, at least a portion of the encapsulations can be positioned within domes extending upwardly from the layer. In certain embodiments, the encapsulations may comprise pockets formed within the layer. In certain embodiments, a first portion of the encapsulations may comprise a dome and a second portion of the encapsulations may comprise a pocket. In certain embodiments, the encapsulations may comprise a tube embedded within the layer. In certain embodiments, the tube may comprise the non-synthetic materials and/or synthetic materials described herein, such as PLA. In at least one embodiment, the tissue thickness compensator may comprise a bioabsorbable foam, such as ORC, comprising PLA tubes embedded therein, and the tube may encapsulate a hydrogel, for example. In certain embodiments, the encapsulations may comprise discrete cells that are unconnected to each other. In certain embodiments, one or more of the encapsulations can be in fluid communication with each other via one or more passageways, conduits, and/or channels, for example, extending through the layer.

The rate of release of a component from the encapsulation may be controlled by the thickness of the tissue thickness compensator, the composition of tissue thickness compensator, the size of the component, the hydrophilicity of the component, and/or the physical and/or chemical interactions among the component, the composition of the tissue thickness compensator, and/or the surgical instrument, for example. In various embodiments, the layer can comprise one or more thin sections or weakened portions, such as partial perforations, for example, which can facilitate the incision of the layer and the rupture of the encapsulations. In various embodiments, the partial perforations may not completely extend through a layer while, in certain embodiments, perforations may completely extend through the layer.

Referring to FIGS. **194** and **195**, in various embodiments, a tissue thickness compensator **70150** may comprise an outer layer **70152**A and an inner layer **70152**B comprising encapsulations **70154**. In certain embodiments, the encapsulation may comprise a first encapsulated component and a second encapsulated component. In certain embodiments, the encapsulations may independently comprise one of a first encapsulated component and a second encapsulated component. The first encapsulated component may be separated from the second encapsulated component. The outer layer **70152**A may comprise a tissue-contacting surface. The inner layer **70152**B may comprise an instrument-contacting surface. The instrument-contacting surface **70152**B may be releasably attached to the anvil **70156**. The outer layer **70152**A may be attached to the inner layer **70152**B to define a void between the outer layer **70152**A and inner layer **70152**B. As shown in FIG. **194**, each encapsulation **70154** may comprise a dome on the instrument-contacting surface of the inner layer **70152**B. The dome may comprise partial perforations to facilitate the incision of the layer by the staple legs and the rupture of the encapsulation. As shown in the FIG. **195**, the anvil **70156** can comprise a plurality of forming pocket rows **70158** wherein the domes of the encapsulations **70154** may be aligned with the forming pocket **70158**. The tissue-contacting surface may comprise a flat surface lacking domes. In certain embodiments, the tissue-contacting surface may comprise one or more encapsulations, such as encapsulations **70154**, for example, extending therefrom.

In various embodiments, an anvil may comprise a tissue thickness compensator comprising an encapsulated component comprising at least one microsphere particle. In certain embodiments, the tissue thickness compensator may comprise an encapsulation comprising a first encapsulated component and a second encapsulated component. In certain embodiments, the tissue thickness compensator may comprise an encapsulation comprising a first microsphere particle and a second microsphere particle.

In various embodiments, referring to FIG. **196**, a stapling apparatus may comprise an anvil **70180** and a staple cartridge (illustrated in other figures). The staples **70190** of a staple cartridge can be deformed by an anvil **70180** when the anvil **70180** is moved into a closed position and/or by a staple driver system **70192** which moves the staples **70190** toward the closed anvil **70180**. The legs **70194** of the staples may contact the anvil **70180** such that the staples **70190** are at least partially deformed. The anvil **70180** may comprise a tissue thickness compensator **70182** comprising an outer layer **70183**A, an inner layer **70183**B. The tissue thickness compensator **70182** may comprise a first encapsulated component and a second encapsulated component. In certain embodiments, the encapsulations **210185** can be aligned, or at least substantially aligned, such that, when the staple legs **70194** are pushed through the tissue T and the outer layer **70183**A, the staple legs **70194** can puncture and/or otherwise rupture the encapsulations **70185**. As shown in FIG. **196**, the staple **70190**C is in its fully fired position, the staple **70190**B is in the process of being fired, and the staple **70190**A is in its unfired position. The legs of staples **70190**C and **70190**B have moved through the tissue T, the outer layer **70183**A, and the inner layer **70183**B of the tissue thickness compensator **70182**, and have contacted an anvil **70180** positioned opposite the staple cartridge. After the encapsulations **70185** have been ruptured, the encapsulated components can flow out and contact each other, bodily fluids, and/or the tissue T, for example. The encapsulated components may react to form a reaction product such as a hydrogel, for example, to expand between the tissue T and the base of the staple and to push the tissue T against the legs of the staple. In various circumstances, as a result of the above, the tissue thickness compensator can be configured to consume any gaps within the staple entrapment area.

In various embodiments, the tissue thickness compensator may be suitable for use with a surgical instrument. As described above the tissue thickness compensator may be associated with the staple cartridge and/or the anvil. The tissue thickness compensator may be configured into any shape, size and/or dimension suitable to fit the staple cartridge and/or anvil. As described herein, the tissue thickness compensator may be releasably attached to the staple cartridge and/or anvil. The tissue thickness compensator may be attached to the staple cartridge and/or anvil in any mechanical and/or chemical manner capable of retaining the tissue thickness compensator in contact with the staple cartridge and/or anvil prior to and during the stapling process. The tissue thickness compensator may be removed or released from the staple cartridge and/or anvil after the staple penetrates the tissue thickness compensator. The tissue thickness compensator may be removed or released from the staple cartridge and/or anvil as the staple cartridge and/or anvil is moved away from the tissue thickness compensator.

Referring to FIGS. **191-193**, stapling apparatus **70118** may comprise an anvil **70120** and a staple cartridge **70122** comprising a firing member **70124**, a plurality of staples **70128**, a knife edge **70129**, and a tissue thickness compensator **70130**. The tissue thickness compensator **70130** may comprise at least one encapsulated component. The encapsulated component may be ruptured when the tissue thickness compensator is compressed, stapled, and/or cut. Referring to FIG. **192**, for example, the staples **70128** can be deployed between an unfired position and a fired position such that the staple legs move through the tissue thickness compensator **70130**, penetrate through a bottom surface and a top surface of the tissue thickness compensator **70130**, penetrate the tissue T, and contact an anvil **70120** positioned opposite the staple cartridge **70118**. The encapsulated components may react with each other, a hydrophilic powder embedded or dispersed in the tissue thickness compensator, and/or bodily fluids to expand or swell the tissue thickness compensator **70130**. As the legs are deformed against the anvil, the legs of each staple can capture a portion of the tissue thickness compensator **70130** and a portion of the tissue T within each staple **70128** and apply a compressive force to the tissue T. As shown in FIGS. **192** and **193**, the tissue thickness compensator **70130** can compensate for the thickness of the tissue T captured within each staple **70128**.

Referring to FIG. **197**, a surgical instrument **70200** may comprise an anvil **70205** comprising an upper tissue thickness compensator **70210** and a staple cartridge **70215** comprising a lower tissue thickness compensator comprising an outer layer **70220** and an inner layer **70225**. The upper tissue thickness compensator **70210** can be positioned on a first side of the targeted tissue and the lower tissue thickness compensator can be positioned on a second side of the tissue. In certain embodiments, the upper tissue thickness compensator **70210** may comprise ORC, the outer layer of the lower tissue thickness compensator may comprise a hydrogel having ORC particles embedded therein, and the inner layer of the lower tissue thickness compensator may comprise ORC, for example.

Referring to FIGS. **200-202**, in various embodiments, a surgical instrument **70400** may comprise a staple cartridge **70405** and an anvil **70410**. The staple cartridge **70405** may comprise a tissue thickness compensator **70415** including bioabsorbable foam. In various embodiments, the bioabsorbable foam can comprise an encapsulation which comprises an encapsulated component **70420**. The bioabsorbable foam may comprise ORC and the encapsulated component may comprise a medicament, for example. The tissue thickness compensator **70415** of the anvil **70410** may comprise an inner layer **70425** and an outer layer **70430**. The inner layer **70425** may comprise a bioabsorbable foam, and the outer layer **70430** may comprise a hydrogel, optionally comprising reinforcement materials, for example. During an exemplary firing sequence, referring primarily to FIG. **201**, a sled **70435** can first contact staple **70440**A and begin to lift the staple upwardly. As the sled **70435** is advanced further distally, the sled **70435** can begin to lift staples **70440**B-D, and any other subsequent staples, in a sequential order. The sled **70435** can drive the staples **70440** upwardly such that the legs of the staples contact the opposing anvil **70410** and are deformed to a desired shape. With regard to the firing sequence illustrated in FIG. **201**, the staples **70440**A-C have been moved into their fully fired positions, the staple **70440**D is in the process of being fired, and the staple **70420**E is still in its unfired position. The encapsulated component **70470** may be ruptured by the staple legs during the exemplary firing sequence. The encapsulated component **70420** may flow from the encapsulation around the staple legs to contact the tissue T. In various circumstances, additional compression of the tissue thickness compensator can squeeze additional medicament out of the encapsulation. In various embodiments, the medicament can immediately treat the tissue and can reduce bleeding from the tissue.

In various circumstances, a surgeon, or other clinician, may deliver a fluid to the tissue thickness compensator to manufacture a tissue thickness compensator comprising at least one medicament stored and/or absorbed therein. In various embodiments, a staple cartridge and/or anvil may comprise a port configured to provide access to the tissue thickness compensator. Referring to FIG. **203**B, a staple cartridge **70500** may comprise a port **70505** at a distal end thereof, for example. The port **70505** may be configured to receive a needle **70510**, such as a fenestrated needle shown in FIG. **203**A. In at least one embodiment, the clinician may insert a needle **70510** through the port **70505** into the tissue thickness compensator **70515** to deliver the fluid to the tissue thickness compensator **70515**. In various embodiments, the fluid may comprise a medicament and hydrogel precursor, for example. As described above, the fluid may be released from tissue thickness compensator to the tissue when the tissue thickness compensator is ruptured and/or compressed. For example, the medicament may be released from the tissue thickness compensator **70515** as the tissue thickness compensator **70515** biodegrades.

In various embodiments, referring now to FIG. **14**, a staple cartridge, such as staple cartridge **10000**, for example, can comprise a support portion **10010** and a compressible tissue thickness compensator **10020**. Referring now to FIGS. **16-18**, the support portion **10010** can comprise a deck surface **10011** and a plurality of staple cavities **10012** defined within the support portion **10010**. Each staple cavity **10012** can be sized and configured to removably store a staple, such as a staple **10030**, for example, therein. The staple cartridge **10000** can further comprise a plurality of staple drivers **10040** which can each be configured to support one or more staples **10030** within the staple cavities **10012** when the staples **10030** and the staple drivers **10040** are in their unfired positions. In at least one such embodiment, referring primarily to FIGS. **22** and **23**, each staple driver **10040** can comprise one or more cradles, or troughs, **10041**, for example, which can be configured to support the staples and limit relative movement between the staples **10030** and the staple drivers **10040**. In various embodiments, referring again to FIG. **16**, the staple cartridge **10000** can further comprise a staple-firing sled **10050** which can be moved from a proximal end **10001** to a distal end **10002** of the staple cartridge in order to sequentially lift the staple drivers **10040** and the staples **10030** from their unfired positions toward an anvil positioned opposite the staple cartridge **10000**. In certain embodiments, referring primarily to FIGS. **16** and **18**, each staple **10030** can comprise a base **10031** and one or more legs **10032** extending from the base **10031** wherein each staple can be at least one of substantially U-shaped and substantially V-shaped, for example. In at least one embodiment, the staples **10030** can be configured such that the tips of the staple legs **10032** are recessed with respect to the deck surface **10011** of the support portion **10010** when the staples **10030** are in their unfired positions. In at least one embodiment, the staples **10030** can be configured such that the tips of the staple legs **10032** are flush with respect to the deck surface **10011** of the support portion **10010** when the staples **10030** are in their unfired positions. In at least one embodiment, the staples **10030** can be configured such that the tips of the staple legs **10032**, or at least some portion of the staple legs **10032**, extend above the deck surface **10011** of the support portion **10010** when the staples **10030** are in their unfired positions. In such embodiments, the staple legs **10032** can extend into and can be embedded within the tissue thickness compensator **10020** when the staples **10030** are in their unfired positions. In at least one such embodiment, the staple legs **10032** can extend above the deck surface **10011** by approximately 0.075", for example. In various embodiments, the staple legs **10032** can extend above the deck surface **10011** by a distance between approximately 0.025" and approximately 0.125", for example. In certain embodiments, further to the above, the tissue thickness compensator **10020** can comprise an uncompressed thickness between approximately 0.08" and approximately 0.125", for example.

In use, further to the above and referring primarily to FIG. **31**, an anvil, such as anvil, **10060**, for example, can be moved into a closed position opposite the staple cartridge **10000**. As described in greater detail below, the anvil **10060** can position tissue against the tissue thickness compensator **10020** and, in various embodiments, compress the tissue thickness compensator **10020** against the deck surface **10011** of the support portion **10010**, for example. Once the anvil **10060** has been suitably positioned, the staples **10030** can be deployed, as also illustrated in FIG. **31**. In various embodiments, as mentioned above, the staple-firing sled **10050** can be moved from the proximal end **10001** of the staple cartridge **10000** toward the distal end **10002**, as illustrated in FIG. **32**. As the sled **10050** is advanced, the sled **10050** can contact the staple drivers **10040** and lift the staple drivers **10040** upwardly within the staple cavities **10012**. In at least one embodiment, the sled **10050** and the staple drivers **10040** can each comprise one or more ramps, or inclined surfaces, which can co-operate to move the staple drivers **10040** upwardly from their unfired positions. In at least one such embodiment, referring to FIGS. **19-23**, each staple driver **10040** can comprise at least one inclined surface **10042** and the sled **10050** can comprise one or more inclined surfaces **10052** which can be configured such that the inclined surfaces **10052** can slide under the inclined surface **10042** as the sled **10050** is advanced distally within the staple cartridge. As the staple drivers **10040** are lifted upwardly within their respective staple cavities **10012**, the staple drivers **10040** can lift the staples **10030** upwardly such that the staples **10030** can emerge from their staple cavities **10012** through openings in the staple deck **10011**. During an exemplary firing sequence, referring primarily to FIGS. **25-27**, the sled **10050** can first contact staple **10030***a* and begin to lift the staple **10030***a* upwardly. As the sled **10050** is advanced further distally, the sled **10050** can begin to lift staples **10030***b*, **10030***c*, **10030***d*, **10030***e*, and **10030***f*, and any other subsequent staples, in a sequential order. As illustrated in FIG. **27**, the sled **10050** can drive the staples **10030** upwardly such that the legs **10032** of the staples contact the opposing anvil, are deformed to a desired shape, and ejected therefrom the support portion **10010**. In various circumstances, the sled **10030** can move several staples upwardly at the same time as part of a firing sequence. With regard to the firing sequence illustrated in FIG. **27**, the staples **10030***a* and **10030***b* have been moved into their fully fired positions and ejected from the support portion **10010**, the staples **10030***c* and **10030***d* are in the process of being fired and are at least partially contained within the support portion **10010**, and the staples **10030***e* and **10030***f* are still in their unfired positions.

As discussed above, and referring to FIG. **33**, the staple legs **10032** of the staples **10030** can extend above the deck surface **10011** of the support portion **10010** when the staples **10030** are in their unfired positions. With further regard to this firing sequence illustrated in FIG. **27**, the staples **10030***e* and **10030***f* are illustrated in their unfired position and their staple legs **10032** extend above the deck surface **10011** and into the tissue thickness compensator **10020**. In various embodiments, the tips of the staple legs **10032**, or any other portion of the staple legs **10032**, may not protrude through a top tissue-contacting surface **10021** of the tissue thickness compensator **10020** when the staples **10030** are in their unfired positions. As the staples **10030** are moved from their unfired positions to their fired positions, as illustrated in FIG. **27**, the tips of the staple legs can protrude through the tissue-contacting surface **10032**. In various embodiments, the tips of the staple legs **10032** can comprise sharp tips which can incise and penetrate the tissue thickness compensator **10020**. In certain embodiments, the tissue thickness compensator **10020** can comprise a plurality of apertures which can be configured to receive the staple legs **10032** and allow the staple legs **10032** to slide relative to the tissue thickness compensator **10020**. In certain embodiments, the support portion **10010** can further comprise a plurality of guides **10013** extending from the deck surface **10011**. The guides **10013** can be positioned adjacent to the staple cavity openings in the deck surface **10011** such that the staple legs **10032** can be at least partially supported by the guides **10013**. In certain embodiments, a guide **10013** can be positioned at a proximal end and/or a distal end of a staple cavity opening. In various embodiments, a first guide **10013** can be positioned at a first end of each staple cavity opening and a second guide **10013** can be positioned at a second end of each staple cavity opening such that each first guide **10013** can support a first staple leg **10032** of a staple **10030** and each second guide **10013** can support a second staple leg **10032** of the staple. In at least one embodiment, referring to FIG. **33**, each guide **10013** can comprise a groove or slot, such as groove **10016**, for example, within which a staple leg **10032** can be slidably received. In various embodiments, each guide **10013** can comprise a cleat, protrusion, and/or spike that can extend from the deck surface **10011** and can extend into the tissue thickness compensator **10020**. In at least one embodiment, as discussed in greater detail below, the cleats, protrusions, and/or spikes can reduce relative movement between the tissue thickness compensator **10020** and the support portion **10010**. In certain embodiments, the tips of the staple legs **10032** may be positioned within the guides **10013** and may not extend above the top surfaces of the guides **10013** when the staples **10030** are in their unfired position. In at least such embodiment, the guides **10013** can define a guide height and the staples **10030** may not extend above this guide height when they are in their unfired position.

In various embodiments, a tissue thickness compensator, such as tissue thickness compensator **10020**, for example, can be comprised of a single sheet of material. In at least one embodiment, a tissue thickness compensator can comprise a continuous sheet of material which can cover the entire top deck surface **10011** of the support portion **10010** or, alternatively, cover less than the entire deck surface **10011**. In certain embodiments, the sheet of material can cover the staple cavity openings in the support portion **10010** while, in other embodiments, the sheet of material can comprise openings which can be aligned, or at least partially aligned, with the staple cavity openings. In various embodiments, a tissue thickness compensator can be comprised of multiple layers of material. In some embodiments, referring now to FIG. **15**, a tissue thickness compensator can comprise a compressible core and a wrap surrounding the compressible core. In certain embodiments, a wrap **10022** can be configured to releasably hold the compressible core to the support portion **10010**. In at least one such embodiment, the support portion **10010** can comprise one or more projections, such as projections **10014** (FIG. **18**), for example, extending therefrom which can be received within one or more apertures and/or slots, such as apertures **10024**, for example, defined in the wrap **10022**. The projections **10014** and the apertures **10024** can be configured such that the projections **10014** can retain the wrap **10022** to the support portion **10010**. In at least one embodiment, the ends of the projections **10014** can be deformed, such as by a heat-stake process, for example, in order to enlarge the ends of the projections **10014** and, as a result, limit the relative movement between the wrap **10022** and the support portion **10010**. In at least one embodiment, the wrap **10022** can comprise one or more perforations **10025** which can facilitate the release of the wrap **10022** from the support portion **10010**, as illustrated in FIG. **15**. Referring now to FIG. **24**, a tissue thickness compensator can comprise a wrap **10222** including a plurality of apertures **10223**, wherein the apertures **10223** can be aligned, or at least partially aligned, with the staple cavity openings in the support portion **10010**. In certain embodiments, the core of the tissue thickness compensator can also comprise apertures which are aligned, or at least partially aligned, with the apertures **10223** in the wrap **10222**. In other embodiments, the core of the tissue thickness compensator can comprise a continuous body and can extend underneath the apertures **10223** such that the continuous body covers the staple cavity openings in the deck surface **10011**.

In various embodiments, as described above, a tissue thickness compensator can comprise a wrap for releasably holding a compressible core to the support portion **10010**. In at least one such embodiment, referring to FIG. **16**, a staple cartridge can further comprise retainer clips **10026** which can be configured to inhibit the wrap, and the compressible core, from prematurely detaching from the support portion **10010**. In various embodiments, each retainer clip **10026** can comprise apertures **10028** which can be configured to receive the projections **10014** extending from the support portion **10010** such that the retainer clips **10026** can be retained to the support portion **10010**. In certain embodiments, the retainer clips **10026** can each comprise at least one pan portion **10027** which can extend underneath the support portion **10010** and can support and retain the staple drivers **10040** within the support portion **10010**. In certain embodiments, as described above, a tissue thickness compensator can be removably attached to the support portion **10010** by the staples **10030**. More particularly, as also described above, the legs of the staples **10030** can extend into the tissue thickness compensator **10020** when the staples **10030** are in their unfired position and, as a result, releasably hold the tissue thickness compensator **10020** to the support portion **10010**. In at least one embodiment, the legs of the staples **10030** can be in contact with the sidewalls of their respective staple cavities **10012** wherein, owing to friction between the staple legs **10032** and the sidewalls, the staples **10030** and the tissue thickness compensator **10020** can be retained in position until the staples **10030** are deployed from the staple cartridge **10000**. When the staples **10030** are deployed, the tissue thickness compensator **10020** can be captured within the staples **10030** and held against the stapled tissue T. When the anvil is thereafter moved into an open position to release the tissue T, the support portion **10010** can be moved away from the tissue thickness compensator **10020** which has been fastened to the tissue. In certain embodiments, an adhesive can be utilized to removably hold the tissue thickness compensator **10020** to the support portion **10010**. In at least one embodiment, a two-part adhesive can be utilized wherein, in at least one embodiment, a first part of the adhesive can be placed on the deck surface **10011** and a second part of the adhesive can be placed on the tissue thickness compensator **10020** such that, when the tissue thickness compensator **10020** is placed against the deck surface **10011**, the first part can contact the second part to active the adhesive and detachably bond the tissue thickness compensator **10020** to the support portion **10010**. In various embodiments, any other suitable means could be used to detachably retain the tissue thickness compensator to the support portion of a staple cartridge.

In various embodiments, further to the above, the sled **10050** can be advanced from the proximal end **10001** to the distal end **10002** to fully deploy all of the staples **10030** contained within the staple cartridge **10000**. In at least one embodiment, referring now to FIGS. **56-60**, the sled **10050** can be advanced distally within a longitudinal cavity **10016** within the support portion **10010** by a firing member, or knife bar, **10052** of a surgical stapler. In use, the staple cartridge **10000** can be inserted into a staple cartridge channel in a jaw of the surgical stapler, such as staple cartridge channel **10070**, for example, and the firing member **10052** can be advanced into contact with the sled **10050**, as illustrated in FIG. **56**. As the sled **10050** is advanced distally by the firing member **10052**, the sled **10050** can contact the proximal-most staple driver, or drivers, **10040** and fire, or eject, the staples **10030** from the cartridge body **10010**, as described above. As illustrated in FIG. **56**, the firing member **10052** can further comprise a cutting edge **10053** which can be advanced distally through a knife slot in the support portion **10010** as the staples **10030** are being fired. In various embodiments, a corresponding knife slot can extend through the anvil positioned opposite the staple cartridge **10000** such that, in at least one embodiment, the cutting edge **10053** can extend between the anvil and the support portion **10010** and incise the tissue and the tissue thickness compensator positioned therebetween. In various circumstances, the sled **10050** can be advanced distally by the firing member **10052** until the sled **10050** reaches the distal end **10002** of the staple cartridge **10000**, as illustrated in FIG. **58**. At such point, the firing member **10052** can be retracted proximally. In some embodiments, the sled **10050** can be retracted proximally with the firing member **10052** but, in various embodiments, referring now to FIG. **59**, the sled **10050** can be left behind in the distal end **10002** of the staple cartridge **10000** when the firing member **10052** is retracted. Once the firing member **10052** has been sufficiently retracted, the anvil can be re-opened, the tissue thickness compensator **10020** can be detached from the support portion **10010**, and the remaining non-implanted portion of the expended staple cartridge **10000**, including the support portion **10010**, can be removed from the staple cartridge channel **10070**.

After the expended staple cartridge **10000** has been removed from the staple cartridge channel, further to the above, a new staple cartridge **10000**, or any other suitable staple cartridge, can be inserted into the staple cartridge channel **10070**. In various embodiments, further to the above, the staple cartridge channel **10070**, the firing member **10052**, and/or the staple cartridge **10000** can comprise co-operating features which can prevent the firing member **10052** from being advanced distally a second, or subsequent, time without a new, or unfired, staple cartridge **10000** positioned in the staple cartridge channel **10070**. More particularly, referring again to FIG. **56**, as the firing member **10052** is advanced into contact with the sled **10050** and, when the sled **10050** is in its proximal unfired position, a support nose **10055** of the firing member **10052** can be positioned on and/or over a support ledge **10056** on the sled **10050** such that the firing member **10052** is held in a sufficient upward position to prevent a lock, or beam, **10054** extending from the firing member **10052** from dropping into a lock recess defined within the staple cartridge channel. As the lock **10054** will not drop into the lock recess, in such circumstances, the lock **10054** may not abut a distal sidewall **10057** of the lock recess as the firing member **10052** is advanced. As the firing member **10052** pushes the sled **10050** distally, the firing member **10052** can be supported in its upward firing position owing to the support nose **10055** resting on the support ledge **10056**. When the firing member **10052** is retracted relative to the sled **10050**, as discussed above and illustrated in FIG. **59**, the firing member **10052** can drop downwardly from its upward position as the support nose **10055** is no longer resting on the support ledge **10056** of the sled **10050**. In at least one such embodiment, the surgical staple can comprise a spring **10058**, and/or any other suitable biasing element, which can be configured to bias the firing member **10052** into its downward position. Once the firing member **10052** has been completely retracted, as illustrated in FIG. **60**, the firing member **10052** cannot be advanced distally through the spent staple cartridge **10000** once again. More particularly, the firing member **10052** can't be held in its upper position by the sled **10050** as the sled **10050**, at this point in the operating sequence, has been left behind at the distal end **10002** of the staple cartridge **10000**. Thus, as mentioned above, in the event that the firing member **10052** is advanced once again without replacing the staple cartridge, the lock beam **10054** will contact the sidewall **10057** of the lock recess which will prevent the firing member **10052** from being advanced distally into the staple cartridge **10000** once again. Stated another way, once the spent staple cartridge **10000** has been replaced with a new staple cartridge, the new staple cartridge will have a proximally-positioned sled **10050** which can hold the firing member **10052** in its upper position and allow the firing member **10052** to be advanced distally once again.

As described above, the sled **10050** can be configured to move the staple drivers **10040** between a first, unfired position and a second, fired position in order to eject staples **10030** from the support portion **10010**. In various embodiments, the staple drivers **10040** can be contained within the staple cavities **10012** after the staples **10030** have been ejected from the support portion **10010**. In certain embodiments, the support portion **10010** can comprise one or more retention features which can be configured to block the staple drivers **10040** from being ejected from, or falling out of, the staple cavities **10012**. In various other embodiments, the sled **10050** can be configured to eject the staple drivers **10040** from the support portion **10010** with the staples **10030**. In at least one such embodiment, the staple drivers **10040** can be comprised of a bioabsorbable and/or biocompatible material, such as Ultem, for example. In certain embodiments, the staple drivers can be attached to the staples **10030**. In at least one such embodiment, a staple driver can be molded over and/or around the base of each staple **10030** such that the driver is integrally formed with the staple. U.S. patent application Ser. No. 11/541,123, entitled SURGICAL STAPLES HAVING COMPRESSIBLE OR CRUSHABLE MEMBERS FOR SECURING TISSUE THEREIN AND STAPLING INSTRUMENTS FOR DEPLOYING THE SAME, filed on Sep. 29, 2006, is hereby incorporated by reference in its entirety.

As described above, a surgical stapling instrument can comprise a staple cartridge channel configured to receive a staple cartridge, an anvil rotatably coupled to the staple cartridge channel, and a firing member comprising a knife edge which is movable relative to the anvil and the staple cartridge channel. In use, a staple cartridge can be positioned within the staple cartridge channel and, after the staple cartridge has been at least partially expended, the staple cartridge can be removed from the staple cartridge channel and replaced with a new staple cartridge. In some such embodiments, the staple cartridge channel, the anvil, and/or the firing member of the surgical stapling instrument may be re-used with the replacement staple cartridge. In certain other embodiments, a staple cartridge may comprise a part of a disposable loading unit assembly which can include a staple cartridge channel, an anvil, and/or a firing member, for example, which can be replaced along with the staple cartridge as part of replacing the disposable loading unit assembly. Certain disposable loading unit assemblies are disclosed in U.S. patent application Ser. No. 12/031,817, entitled END EFFECTOR COUPLING ARRANGEMENTS FOR A SURGICAL CUTTING AND STAPLING INSTRUMENT, which was filed on Feb. 15, 2008, now U.S. Patent Application Publication No. 2009/0206131, the entire disclosure of which is incorporated by reference herein.

In various embodiments, the tissue thickness compensator may comprise an extrudable, a castable, and/or moldable composition comprising at least one of the synthetic and/or non-synthetic materials described herein. In various embodiments, the tissue thickness compensator may comprise a film or sheet comprising two or more layers. The tissue thickness compensator may be obtained using conventional methods, such as, for example, mixing, blending, compounding, spraying, wicking, solvent evaporating, dipping, brushing, vapor deposition, extruding, calendaring, casting, molding and the like. In extrusion, an opening may be in the form of a die comprising at least one opening to impart a shape to the emerging extrudate. In calendering, an opening may comprise a nip between two rolls. Conventional molding methods may include, but are not limited to, blow molding, injection molding, foam injection, compression molding, thermoforming, extrusion, foam extrusion, film blowing, calendaring, spinning, solvent welding, coating methods, such as dip coating and spin coating, solution casting and film casting, plastisol processing (including knife coating, roller coating and casting), and combinations thereof. In injection molding, an opening may comprise a nozzle and/or channels/runners and/or mold cavities and features. In compression molding, the composition may be positioned in a mold cavity, heated to a suitable temperature, and shaped by exposure to compression under relatively high pressure. In casting, the composition may comprise a liquid or slurry that may be poured or otherwise provided into, onto and/or around a mold or object to replicate features of the mold or object. After casting, the composition may be dried, cooled, and/or cured to form a solid.

In various embodiments, a method of manufacturing a tissue thickness compensator may generally comprise providing a tissue thickness compensator composition, liquifying the composition to make it flowable, and forming the composition in the molten, semi-molten, or plastic state into a layer and/or film having the desired thickness. Referring to FIG. **198**A, a tissue thickness compensator may be manufactured by dissolving a hydrogel precursor in an aqueous solution, dispersing biocompatible particles and/or fibers therein, providing a mold having biocompatible particles therein, providing the solution into the mold, contacting an activator and the solution, and curing the solution to form the tissue thickness compensator comprising an outer layer comprise biocompatible particles and an inner layer comprising biocompatible particles embedded therein. A shown in FIG. **198**A, a biocompatible layer **70250** may be provided in the bottom of a mold **70260**, and an aqueous solution of a hydrogel precursor **70255** having biocompatible particles **70257** disposed therein may be provided to the mold **70260**, and the aqueous solution may be cured to form a tissue thickness compensator having a first layer comprising a biocompatible material, such as ORC, for example, and a second layer comprising a hydrogel having biocompatible fibers, such as ORC fibers, disposed therein. The tissue thickness compensator may comprise a foam comprising an outer layer comprise biocompatible particles and an inner layer comprising biocompatible particles embedded therein. In at least one embodiment, a tissue thickness compensator may be manufactured by dissolving a sodium alginater in water, dispersing ORC particles therein, providing a mold having ORC particles therein, pouring the solution into the mold, spraying or infusing calcium chloride to contact the solution to initiate crosslinking of the sodium alginater, freeze drying the hydrogel to form the tissue thickness compensator comprising an outer layer comprising ORC and an inner layer comprising a hydrogel and ORC particles embedded therein.

Referring to FIG. **198**B, in various embodiments, a method of manufacturing a trilayer tissue thickness compensator may generally comprise by dissolving a first hydrogel precursor in a first aqueous solution, dispersing biocompatible particles and/or fibers in the first aqueous solution, providing a mold **70260** having a first layer **70250** of biocompatible particles therein, providing the first aqueous solution into the mold, contacting an activator and the first aqueous solution, curing the first aqueous solution to form a second layer **70255**, dissolving a second hydrogel precursor in a second aqueous solution, providing the second aqueous solution into the mold, curing the second aqueous solution to form a third layer **70265**. In at least one embodiment, a trilayer tissue thickness compensator may be manufactured by dissolving a sodium alginater in water to form a first aqueous solution, dispersing ORC particles in the first aqueous solution, providing a mold having a first layer of ORC particles therein, pouring the first aqueous solution into the mold, spraying or infusing calcium chloride to contact the first aqueous solution to initiate crosslinking of the sodium alginater, freeze drying the first aqueous solution to form a second layer comprising a hydrogel having ORC particles embedded therein, dissolving a sodium alginater in water to form a second aqueous solution, pouring the second aqueous solution into the mold, spraying or infusing calcium chloride to contact the second aqueous solution to initiate crosslinking of the sodium alginater, freeze drying the second aqueous solution to form a third layer comprising a hydrogel.

In various embodiments, a method of manufacturing a tissue thickness compensator comprising at least one medicament stored and/or absorbed therein may generally comprise providing a tissue thickness compensator and contacting the tissue thickness compensator and the medicament to retain the medicament in the tissue thickness compensator. In at least one embodiment, a method of manufacturing a tissue thickness compensator comprising an antibacterial material may comprise providing a hydrogel, drying the hydrogel, swelling the hydrogel in an aqueous solution of silver nitrate, contacting the hydrogel and a solution of sodium chloride to form the tissue thickness compensator having antibacterial properties. The tissue thickness compensator may comprise silver dispersed therein.

Referring to FIG. **204**, in various embodiments, a method for manufacturing a tissue thickness compensator may comprise co-extrusion and/or bonding. In various embodiments, the tissue thickness compensator **70550** may comprise a laminate comprising a first layer **70555** and a second layer **70560** sealingly enclosing an inner layer **70565** comprising a hydrogel, for example. The hydrogel may comprise a dry film, a dry foam, a powder, and/or granules, for example. The hydrogel may comprise super absorbent materials, such as, for example, polyvinylpyrrolidone, carboxy methylcellulose, poly sulfur propyl acrylate. The first and/or second layers may be made in-line by feeding raw materials of the first and second layers, respectively, into an extruder from a hopper, and thereafter supplying the first and second layers. The raw materials of the inner layer **70565** may be added to a hopper of an extruder. The raw materials can be dispersively mixed and compounded at an elevated temperature within the extruder. As the raw materials exit the die **70570** at an opening, the inner layer **70565** may be deposited onto a surface of the first layer **70555**. In various embodiments, the tissue thickness compensator may comprise a foam, film, powder, and/or granule. The first and second layers **70555** and **70560** may be positioned in the face-to-face relationship. The second layer **70560** may be aligned with the first layer **70555** in a face-to-face relationship by a roller **70575**. The first layer **70555** may adhere to the second layer **70560** wherein the first and second layers **70555**, **70560** may physically entrap the inner layer **70565**. The layers may be joined together under light pressure, under conventional calendar bonding processes, and/or through the use of adhesives, for example, to form the tissue thickness compensator **70550**. In at least one embodiment, as shown in FIG. **78**, the first and second layers **70555** and **70560** may be joined together through a rolling process utilizing a grooved roller **70580**, for example. In various embodiments, as a result of the above, the inner layer **70565** may be contained and/or sealed by the first and second layers **70555** and **70560** which can collectively form an outer layer, or barrier. The outer layer may prevent or reduce moisture from contacting the inner layer **70565** until the outer layer is ruptured.

Referring to FIG. **61**, an end effector **12** for a surgical instrument **10** (FIG. **1**) can be configured to receive a fastener cartridge assembly, such as staple cartridge **20000**, for example. As illustrated in FIG. **61**, the staple cartridge **20000** can be configured to fit in a cartridge channel **20072** of a jaw **20070** of the end effector **12**. In other embodiments, the staple cartridge **20000** can be integral to the end effector **12** such that the staple cartridge **20000** and the end effector **12** are formed as a single unit construction. The staple cartridge **20000** can comprise a first body portion, such as rigid support portion

20010, for example. The staple cartridge 20000 can also comprise a second body portion, such as a compressible portion or a tissue thickness compensator 20020, for example. In other embodiments, the tissue thickness compensator 20020 may not comprise an integral part of the staple cartridge 20000 but may be otherwise positioned relative to the end effector 12. For example, the tissue thickness compensator 20020 can be secured to an anvil 20060 of the end effector 12 or can be otherwise retained in the end effector 12. In at least one embodiment, referring to FIG. 78, the staple cartridge can further comprise retainer clips 20126 which can be configured to inhibit the tissue thickness compensator 20020 from prematurely detaching from the support portion 20010. The reader will appreciate that the tissue thickness compensators described herein can be installed in or otherwise engaged with a variety of end effectors and that such embodiments are within the scope of the present disclosure.

Similar to the tissue thickness compensators described herein, referring now to FIG. 78, the tissue thickness compensator 20020 can be released from or disengaged with the surgical end effector 12. For example, in some embodiments, the rigid support portion 20010 of the staple cartridge 20000 can remain engaged with the fastener cartridge channel 20072 of the end effector jaw 20070 while the tissue thickness compensator 20020 disengages from the rigid support portion 20010. In various embodiments, the tissue thickness compensator 20020 can release from the end effector 12 after staples 20030 (FIGS. 78-83) are deployed from staple cavities 20012 in the rigid support portion 2010, similar to various embodiments described herein. Staples 20030 can be fired from staple cavities 20012 such that the staples 20030 engage the tissue thickness compensator 20020. Also similar to various embodiments described herein, referring generally to FIGS. 63, 82 and 83, a staple 20030 can capture a portion of the tissue thickness compensator 20020 along with stapled tissue T. In some embodiments, the tissue thickness compensator 20020 can be deformable and the portion of the tissue thickness compensator 20020 that is captured within a fired staple 20030 can be compressed. Similar to the tissue thickness compensators described herein, the tissue thickness compensator 20020 can compensate for different thicknesses, compressibilities, and/or densities of tissue T captured within each staple 20030. Further, as also described herein, the tissue thickness compensator 20020 can compensate for gaps created by malformed staples 20030.

The tissue thickness compensator 20020 can be compressible between non-compressed height(s) and compressed height(s). Referring to FIG. 78, the tissue thickness compensator 20020 can have a top surface 20021 and a bottom surface 20022. The height of the tissue thickness compensator can be the distance between the top surface 20021 and the bottom surface 20022. In various embodiments, the non-compressed height of the tissue thickness compensator 20020 can be the distance between the top surface 20021 and the bottom surface 20022 when minimal or no force is applied to the tissue thickness compensator 20020, i.e., when the tissue thickness compensator 20020 is not compressed. The compressed height of the tissue thickness compensator 20020 can be the distance between the top surface 20021 and the bottom surface 20022 when a force is applied to the tissue thickness compensator 20020, such as when a fired staple 20030 captures a portion of the tissue thickness compensator 20020, for example. The tissue thickness compensator 20020 can have a distal end 20025 and a proximal end 20026. As illustrated in FIG. 78, the non-compressed height of the tissue thickness compensator 20020 can be uniform between the distal end 20025 and the proximal end 20026 of the tissue thickness compensator 20020. In other embodiments, the non-compressed height can vary between the distal end 20025 and the proximal end 20026. For example, the top surface 20021 and/or bottom surface 20022 of the tissue thickness compensator 20020 can be angled and/or stepped relative to the other such that the non-compressed height varies between the proximal end 20026 and the distal end 20025. In some embodiments, the non-compressed height of the tissue thickness compensator 20020 can be approximately 0.08 inches, for example. In other embodiments, the non-compressed height of the tissue thickness compensator 20020 can vary between approximately 0.025 inches and approximately 0.10 inches, for example.

As described in greater detail herein, the tissue thickness compensator 20020 can be compressed to different compressed heights between the proximal end 20026 and the distal end 20025 thereof. In other embodiments, the tissue thickness compensator 20020 can be uniformly compressed throughout the length thereof. The compressed height(s) of the tissue thickness compensator 20020 can depend on the geometry of the end effector 12, characteristics of the tissue thickness compensator 20020, the engaged tissue T and/or the staples 20030, for example. In various embodiments, the compressed height of the tissue thickness compensator 20020 can relate to the tissue gap in the end effector 12. In various embodiments, when the anvil 20060 is clamped towards the staple cartridge 20000, the tissue gap can be defined between a top deck surface 20011 (FIG. 78) of the staple cartridge 20000 and a tissue contacting surface 20061 (FIG. 61) of the anvil 20060, for example. The tissue gap can be approximately 0.025 inches or approximately 0.100 inches, for example. In some embodiments, the tissue gap can be approximately 0.750 millimeters or approximately 3.500 millimeters, for example. In various embodiments, the compressed height of the tissue thickness compensator 20020 can equal or substantially equal the tissue gap, for example. When tissue T is positioned within the tissue gap of the end effector 12, the compressed height of the tissue thickness compensator can be less in order to accommodate the tissue T. For example, where the tissue gap is approximately 0.750 millimeters, the compressed height of the tissue thickness compensator can be approximately 0.500 millimeters. In embodiments where the tissue gap is approximately 3.500 millimeters, the compressed height of the tissue thickness compensator 20020 can be approximately 2.5 mm, for example. Furthermore, the tissue thickness compensator 20020 can comprise a minimum compressed height. For example, the minimum compressed height of the tissue thickness compensator 20020 can be approximately 0.250 millimeters. In various embodiments, the tissue gap defined between the deck surface of the staple cartridge and the tissue contacting surface of the anvil can equal, or at least substantially equal, the uncompressed height of the tissue thickness compensator, for example.

Referring primarily to FIG. 62, the tissue thickness compensator 20020 can comprise a fibrous, nonwoven material 20080 including fibers 20082. In some embodiments, the tissue thickness compensator 20020 can comprise felt or a felt-like material. Fibers 20082 in the nonwoven material 20080 can be fastened together by any means known in the art, including, but not limited to, needle-punching, thermal bonding, hydro-entanglement, ultrasonic pattern bonding, chemical bonding, and meltblown bonding. Further, in various embodiments, layers of nonwoven material 20080 can be mechanically, thermally, or chemically fastened together to form the tissue thickness compensator 20020. As described in greater detail herein, the fibrous, nonwoven material 20080 can be compressible, which can enable compression of the tissue thickness compensator **20020**. In various embodiments, the tissue thickness compensator **20020** can comprise a non-compressible portion as well. For example, the tissue thickness compensator **20020** can comprise a compressible nonwoven material **20080** and a non-compressible portion.

Still referring primarily to FIG. **62**, the nonwoven material **20080** can comprise a plurality of fibers **20082**. At least some of the fibers **20082** in the nonwoven material **20080** can be crimped fibers **20086**. The crimped fibers **20086** can be, for example, crimped, twisted, coiled, bent, crippled, spiraled, curled, and/or bowed within the nonwoven material **20080**. As described in greater detail herein, the crimped fibers **20086** can be formed in any suitable shape such that deformation of the crimped fibers **20086** generates a spring load or restoring force. In some embodiments, the crimped fibers **20086** can be heat-shaped to form a coiled or substantially coil-like shape. The crimped fibers **20086** can be formed from non-crimped fibers **20084**. For example, non-crimped fibers **20084** can be wound around a heated mandrel to form a substantially coil-like shape.

In various embodiments, the tissue thickness compensator **20020** can comprise a homogeneous absorbable polymer matrix. The homogenous absorbable polymer matrix can comprise a foam, gel, and/or film, for example. Further, the plurality of fibers **20082** can be dispersed throughout the homogenous absorbable polymer matrix. At least some of the fibers **20082** in the homogenous absorbable polymer matrix can be crimped fibers **20086**, for example. As described in greater detail herein, the homogeneous absorbable polymer matrix of the tissue thickness compensator **2002** can be compressible.

In various embodiments, referring to FIGS. **65** and **66**, crimped fibers **20086** can be randomly dispersed throughout at least a portion of the nonwoven material **20080**. For example, crimped fibers **20086** can be randomly dispersed throughout the nonwoven material **20080** such that a portion of the nonwoven material **20080** comprises more crimped fibers **20086** than other portions of the nonwoven material **20080**. Further, the crimped fibers **20086** can congregate in fiber clusters **20085*a***, **20085*b***, **20085*c***, **20085*d*** and **20085*e***, for example, in the nonwoven material **20080**. The shape of the crimped fibers **20086** can cause entanglement of the fibers **20086** during manufacturing of the nonwoven material **20080**; entanglement of the crimped fibers **20086** can, in turn, result in the formation of the fiber clusters **20085*a***, **20085*b***, **20085*c***, **20085*d*** and **20085*e***. Additionally or alternatively, crimped fibers **20086** can be randomly oriented throughout the nonwoven material **20080**. For example, referring to FIG. **62**, a first crimped fiber **20086*a*** can be oriented in a first direction, a second crimped fiber **20086*b*** can be oriented in a second direction, and a third crimped fiber **20086*c*** can be oriented in a third direction.

In some embodiments, the crimped fibers **20086** can be systematically distributed and/or arranged throughout at least a portion of the nonwoven material **20080**. For example, referring now to FIG. **67**, crimped fibers **20186** can be positioned in an arrangement **20185**, in which a plurality of crimped fibers **20186*a*** are arranged in a first direction and another plurality of crimped fibers **20186*b*** are arranged in a second direction. The crimped fibers **20186** can overlap such that they become entangled or interconnected with each other. In various embodiments, the crimped fibers **20186** can be systematically arranged such that a crimped fiber **20186*a*** is substantially parallel to another crimped fiber **20186*a***. Still another crimped fiber **20186*b*** can be substantially transverse to some crimped fibers **20186*a***. In various embodiments, crimped fibers **20186*a*** can be substantially aligned with a first axis Y and crimped fibers **20186*b*** can be substantially aligned with a second axis X. In some embodiments the first axis Y can be perpendicular or substantially perpendicular to the second axis X, for example.

Referring primarily to FIG. **68**, in various embodiments, crimped fibers **20286** can be arranged in an arrangement **20285**. In some embodiments, each crimped fibers **20286** can comprise a longitudinal axis defined between a first end **20287** and a second end **20289** of the crimped fiber **20286**. In some embodiments, the crimped fibers **20286** can be systematically distributed in the nonwoven material **20080** such that a first end **20287** of one crimped fiber **20286** is positioned adjacent to a second end **20289** of another crimped fiber **20286**. In another embodiment, referring now to FIG. **69**, a fiber arrangement **20385** can comprise a first crimped fiber **20386*a*** oriented in a first direction, a second crimped fiber **20386*b*** oriented in a second direction, and a third crimped fiber **20386*c*** oriented in a third direction, for example. In various embodiments, a single pattern or arrangement of crimped fibers **20286** can be repeated throughout the nonwoven material **20080**. In at least one embodiment, crimped fibers can be arranged in different patterns throughout the nonwoven material **20080**. In still other embodiments, the nonwoven material **20080** can comprise at least one pattern of crimped fibers, as well as a plurality of randomly oriented and/or randomly distributed crimped fibers.

Referring again to FIG. **62**, the plurality of fibers **20082** in the nonwoven material **20080** can comprise at least some non-crimped fibers **20084**. The non-crimped fibers **20084** and crimped fibers **20086** in the nonwoven material **20080** can be entangled or interconnected. In one embodiment, the ratio of crimped fibers **20086** to non-crimped fibers **20084** can be approximately 25:1, for example. In another embodiment, the ratio of crimped fibers **20086** to non-crimped fibers **20084** can be approximately 1:25, for example. In other embodiments, the ratio of crimped fibers **20086** to non-crimped fibers **20084** can be approximately 1:1, for example. As described in greater detail herein, the number of crimped fibers **20086** per unit volume of nonwoven material **20080** can affect the restoring force generated by the nonwoven material **20080** when the nonwoven material **20080** has been deformed. As also described in greater detail herein, the restoring force generated by the nonwoven material **20080** can also depend on, for example, the material, shape, size, position and/or orientation of crimped and non-crimped fibers **20086**, **20084** in the nonwoven material **20080**.

In various embodiments, the fibers **20082** of the nonwoven material **20080** can comprise a polymeric composition. The polymeric composition of the fibers **20082** can comprise non-absorbable polymers, absorbable polymers, or combinations thereof. In some embodiments, the absorbable polymers can include bioabsorbable, biocompatible elastomeric polymers. Furthermore, the polymeric composition of the fibers **20082** can comprise synthetic polymers, non-synthetic polymers, or combinations thereof. Examples of synthetic polymers include, but are not limited to, polyglycolic acid (PGA), poly (lactic acid) (PLA), polycaprolactone (PCL), polydioxanone (PDO), and copolymers thereof. For example, the fibers **20082** can comprise a 90/10 poly(glycolide-L-lactide) copolymer, such as, for example, the copolymer commercially available from Ethicon, Inc. under the trade designation "VICRYL (polyglactic 910)." Examples of non-synthetic polymers include, but are not limited to, lyophilized polysaccharide, glycoprotein, elastin, proteoglycan, gelatin, collagen, and oxidized regenerated cellulose (ORC). In various embodiments, similar to the polymeric compositions in tissue thickness compensators described herein, the polymeric composition of the fibers **20082** can include varied amounts of absorbable polymers, non-absorbable polymers, synthetic polymers, and/or non-synthetic polymers, for example, by weight percentage.

In some embodiments, the crimped fibers **20086** of the nonwoven material **20080** can comprise a first polymeric composition and the non-crimped fibers **20084** of the nonwoven material **20080** can comprise a different polymeric composition. For example, the crimped fibers **20086** can comprise synthetic polymer(s), such as, for example, 90/10 poly(glycolide-L-lactide), while the non-crimped fibers **20084** can comprise non-synthetic polymer(s), such as, for example, oxidized regenerated cellulose. In other embodiments, the crimped fibers **20086** and the non-crimped fibers **20084** can comprise the same polymeric composition.

As described herein, crimped fibers **20086** and non-crimped fibers **20084** can be fastened together, for example, by needle-punching, thermal bonding, hydro-entanglement, ultrasonic pattern bonding, chemical bonding, and meltblown bonding. In some embodiments, crimped fibers **20086** comprising synthetic polymers such as, for example, "VICRYL (polyglactic 910)", and non-crimped fibers **20084** comprising oxidized regenerated cellulose can be needle-punched together to form the nonwoven material **20080**. In various embodiments, the nonwoven material **20080** can comprise approximately 5% to 50% crimped "VICRYL (polyglactic 910)" fibers **20086** by weight and approximately 5% to 50% non-crimped oxidized regenerated cellulose (ORC) fibers **20084** by weight, for example. When the nonwoven material **20080** contacts tissue T, the non-crimped ORC fibers **20084** can rapidly react with plasma in the tissue to form a gelatinous mass, for example. In various embodiments, the formation of the gelatinous ORC mass can be instantaneous or nearly instantaneous with the tissue contact. Further, after the formation of the gelatinous ORC mass, the crimped "VICRYL (polyglactic 910)" fibers **20086** can remain dispersed throughout the nonwoven material **20080**. For example, the crimped fibers **20086** can be suspended in the gelatinous ORC mass. As the gelatinous ORC mass is bioabsorbed, the crimped "VICRYL (polyglactic 910)" fibers **20086** can exert a springback force on adjacent tissue, as described in greater detail herein. Further, the tissue can begin to heal around the "VICRYL (polyglactic 910)" fibers and/or the formed staples **30030**, as also described in greater detail herein.

In at least one embodiment, referring primarily to FIGS. **78-81**, the support portion **20010** of the staple cartridge **20000** can comprise a cartridge body **20017**, a top deck surface **20011**, and a plurality of staple cavities **20012**. Similar to the embodiments described herein, each staple cavity **20012** can define an opening in the deck surface **20011**. A staple **20030** can be removably positioned in a staple cavity **20012**. In various embodiments, a single staple **20030** is disposed in each staple cavity **20012**. In at least one embodiment, referring primarily to FIGS. **82** and **83** and similar to the staples described herein, each staple **20030** can comprise a base **20031** having a first end **20035** and a second end **20036**. A staple leg **20032** can extend from the first end **20035** of the base **20031** and another staple leg **20032** can extend from the second end **20036** of the base **20031**. Referring again to FIGS. **78-81**, prior to the deployment of the staples **20030**, the base **20031** of each staple **20030** can be supported by a staple driver **20040** positioned within the rigid support portion **20010** of the staple cartridge **20000**. Also prior to deployment of the staples **20030**, the legs **20032** of each staple **20030** can be at least partially contained within a staple cavity **20012**.

In various embodiments, the staples **20030** can be deployed between an initial position and a fired position. For example, referring primarily to FIG. **81**, staples **20030** can be in an initial position (staples **20030***e*, **20030***f*), a partially fired or intermediate position (staples **20030***c*, **20030***d*), or a fired position (staples **20030***a*, **20030***b*). A driver **20040** can motivate the staples between the initial position and the fired position. For example, the base **20031** of each staple **20030** can be supported by a driver **20040**. The legs **20032** of a staple (staples **20030***e*, **20030***f* in FIG. **80**, for example) can be positioned within a staple cavity **20012**. As the firing member or staple-firing sled **20050** translates from the proximal end **20001** to the distal end **20002** of the staple cartridge **20000**, an inclined surface **20051** on the sled **20050** can contact an inclined surface **20042** on a driver **20040** to deploy the staple **20030** positioned above to the contacted driver **20040**. In various embodiments, the staples **20030** can be deployed between an initial position and a fired position such that the legs **20032** move through the nonwoven material **20080** of the tissue thickness compensator **20020**, penetrate the top surface **20021** of the tissue thickness compensator **20020**, penetrate tissue T, and contact an anvil **20060** (FIG. **61**) positioned opposite the staple cartridge **20000** in the end effector **12**. The staple legs **20032** can be deformed against the anvil **20060** and the legs **20032** of each staple **20030** can capture a portion of the nonwoven material **20080** and a portion of the tissue T.

In the fired configuration (FIGS. **82** and **83**), each staple **20030** can apply a compressive force to the tissue T and to the tissue thickness compensator **20020** captured within the staple **20030**. Referring primarily to FIGS. **80** and **81**, the legs **20032** of each staple **20030** can be deformed downwardly toward the base **20031** of the staple **20030** to form a staple entrapment area **20039**. The staple entrapment area **20039** can be the area in which the tissue T and the tissue thickness compensator **20020** can be captured by a fired staple **20030**. In various circumstances, the staple entrapment area **20039** can be defined between the inner surfaces of the deformed legs **20032** and the inner surface of the base **20031** of a staple **20030**. The size of the entrapment area **20039** for a staple **20030** can depend on several factors such as the length of the legs, the diameter of the legs, the width of the base, and/or the extent in which the legs are deformed, for example.

In various embodiments, when a nonwoven material **20080** is captured in a staple entrapment area **20039**, the captured portion of the nonwoven material **20080** can be compressed. The compressed height of the nonwoven material **20080** captured in a staple entrapment area **20039** can vary within the staple cartridge **20000** depending on the tissue T in that same staple entrapment area **20039**. For example, where the tissue T is thinner, the staple entrapment area **20039** may have more room for the nonwoven material **20080** and, as a result, the nonwoven material **20080** may not be as compressed as it would be if the tissue T were thicker. Where the tissue T is thicker, the nonwoven material **20080** can be compressed more to accommodate the thicker tissue T, for example. For example, referring to FIG. **82**, the nonwoven material **20080** can be compressed to a first height in a first staple entrapment area **20039***a*, a second height in a second staple entrapment area **20039***b*, a third height in a third staple entrapment area **20039***c*, a fourth height in a fourth staple entrapment area **20039***d*, and a fifth height in a fifth staple entrapment area **20039***e*, for example. Similarly, as illustrated in FIG. **83**, the nonwoven material **20080** can be compressed to a first height in the first staple entrapment area **20039***a*, a second height in the second staple entrapment area **20039***b*, a third height in the third staple entrapment area **20039***c*, and a fourth height in the fourth staple entrapment area **20039***d*. In other embodiments, the compressed height of the nonwoven material **20080** can be uniform throughout the staple cartridge **20010**.

In various embodiments, an applied force can move the nonwoven material **20080** from an initial uncompressed configuration to a compressed configuration. Further, the nonwoven material **20080** can be resilient, such that, when compressed, the nonwoven material **20080** can generate a springback or restoring force. When deformed, the nonwoven material **20080** can seek to rebound from the compressed or deformed configuration. As the nonwoven material **20080** seeks to rebound, it can exert a springback or restoring force on the tissue also captured in the staple entrapment area **30039**, as described in greater detail herein. When the applied force is subsequently removed, the restoring force can cause the nonwoven material to rebound from the compressed configuration. In various embodiments, the nonwoven material **20080** can rebound to the initial, uncompressed configuration or may rebound to a configuration substantially similar to the initial, uncompressed configuration. In various embodiments, the deformation of the nonwoven material **20080** can be elastic. In some embodiments, the deformation of the nonwoven material can be partially elastic and partially plastic.

When a portion of the nonwoven material **20080** is compressed in a staple entrapment area **20039**, the crimped fibers **20086** in that portion of the nonwoven compensator **20039** can also be compressed or otherwise deformed. The amount a crimped fiber **20086** is deformed can correspond to the amount that the captured portion of the nonwoven material **20080** is compressed. For example, referring to FIG. **63**, the nonwoven material **20080** can be captured by deployed staples **20030**. Where the nonwoven material **20080** is more compressed by a deployed staple **20030**, the average deformation of crimped fibers **20086** can be greater. Further, where the nonwoven material **20080** is less compressed by a deployed staple, the average deformation of crimped fibers **20086** can be smaller. Similarly, referring to FIGS. **82** and **83**, in a staple entrapment area **20039*d*** where the nonwoven material **20080** is more compressed, the crimped fibers **20086** in that staple entrapment area **20039*d*** can be, on average, more deformed. Further, in a staple entrapment area **20039*a*** where the nonwoven material **20080** is less compressed, the crimped fibers **20086** in that staple entrapment area **20039*a*** can be, on average, less deformed.

The ability of the nonwoven material **20080** to rebound from the deformed configuration, i.e., the resiliency of the nonwoven material **20080**, can be a function of the resiliency of the crimped fibers **20086** in the nonwoven material **20080**. In various embodiments, the crimped fibers **20086** can deform elastically. In some embodiments, deformation of the crimped fibers **20086** can be partially elastic and partially plastic. In various embodiments, compression of each crimped fiber **20086** can cause the compressed crimped fibers **20086** to generate a springback or restoring force. For example, the compressed crimped fibers **20086** can generate a restoring force as the fibers **20086** seek to rebound from their compressed configuration. In various embodiments, the fibers **20086** can seek to return to their initial, uncompressed configuration or to a configuration substantially similar thereto. In some embodiments, the crimped fibers **20086** can seek to partially return to their initial configuration. In various embodiments, only a portion of the crimped fibers **20086** in the nonwoven material **20080** can be resilient. When a crimped fiber **20086** is comprised of a linear-elastic material, the restoring force of the compressed crimped fiber **20086** can be a function of the amount the crimped fiber **20086** is compressed and the spring rate of the crimped fiber **20086**, for example. The spring rate of the crimped fiber **20086** can at least depend on the orientation, material, shape and/or size of the crimped fiber **20086**, for example.

In various embodiments, the crimped fibers **20086** in the nonwoven material **20080** can comprise a uniform spring rate. In other embodiments, the spring rate of the crimped fibers **20086** in the nonwoven material **20080** can vary. When a crimped fiber **20086** having a large spring rate is greatly compressed, the crimped fiber **20086** can generate a large restoring force. When a crimped fiber **20086** having the same large spring rate is less compressed, the crimped fiber **20086** can generate a smaller restoring force. The aggregate of restoring forces generated by compressed crimped fibers **20086** in the nonwoven material **20080** can generate a combined restoring force throughout the nonwoven material **20080** of the tissue thickness compensator **20020**. In various embodiments, the nonwoven material **20080** can exert the combined restoring force on tissue T captured within a fired staple **20030** with the compressed nonwoven material **20080**.

Furthermore, the number of crimped fibers **20086** per unit volume of nonwoven material **20080** can affect the spring rate of the nonwoven material **20080**. For example, the resiliency in a nonwoven material **20080** can be low when the number of crimped fibers **20086** per unit volume of nonwoven material **20080** is low, for example; the resiliency of the nonwoven material **20080** can be higher when the number of crimped fibers **20086** per unit volume of nonwoven material **20080** is higher, for example; and the resiliency of the nonwoven material **20080** can be higher still when the number of crimped fibers **20086** per unit volume of nonwoven material **20080** is even higher, for example. When the resiliency of the nonwoven material **20080** is low, such as when the number of crimped fibers **20086** per unit volume of nonwoven material **20080** is low, the combined restoring force exerted by the tissue thickness compensator **20020** on captured tissue T can also be low. When the resiliency of the nonwoven material **20080** is higher, such as when the number of crimped fibers **20086** per unit volume of nonwoven material **20080** is higher, the aggregate restoring force exerted by the tissue thickness compensator **20020** on captured tissue T can also be higher.

In various embodiments, referring primarily to FIG. **64**, a nonwoven material **20080'** of a tissue thickness compensator **20020'** can comprise a therapeutic agent **20088**, such as a medicament and/or pharmaceutically active agent, for example. In various embodiments, the nonwoven material **20080'** can release a therapeutically effective amount of the therapeutic agent **20088**. For example, the therapeutic agent **20088** can be released as the nonwoven material **20080'** is absorbed. In various embodiments, the therapeutic agent **20088** can be released into fluid, such as blood, for example, passing over or through the nonwoven material **20080'**. Examples of therapeutic agents **20088** can include, but are not limited to, haemostatic agents and drugs such as, for example, fibrin, thrombin, and/or oxidized regenerated cellulose (ORC); anti-inflammatory drugs such as, for example, diclofenac, aspirin, naproxen, sulindac, and/or hydrocortisone; antibiotic and antimicrobial drugs or agents such as, for example, triclosan, ionic silver, ampicillin, gentamicin, polymyxin B, and/or chloramphenicol; and anticancer agents such as, for example, cisplatin, mitomycin, and/or adriamycin. In various embodiments, the therapeutic agent **20088** can comprise a biologic, such as a stem cell, for example. In some embodiments, the fibers **20082** of the nonwoven material **20080'** can comprise the therapeutic agent **20088**. In other embodiments, the therapeutic agent **20088** can be added to the nonwoven material **20080'** or otherwise integrated into the tissue thickness compensator **20020'**.

In some embodiments, primarily referring to FIGS. **70-70**B, a tissue thickness compensator **20520** for an end effector **12** (FIG. **61**) can comprise a plurality of springs or coiled fibers **20586**. Similar to the crimped fibers **20086** described herein, the coiled fibers **20586** can be, for example, crimped, twisted, coiled, bent, crippled, spiraled, curled, and/or bowed within the tissue thickness compensator **20520**. In some embodiments, the coiled fibers **20586** can be wound around a mandrel to form a coiled or substantially coil-like shape. Similar to the embodiments described herein, the coiled fibers **20586** can be randomly oriented and/or randomly distributed throughout the tissue thickness compensator **20520**. In other embodiments, the coiled fibers **20586** can be systematically arranged and/or uniformly distributed throughout the tissue thickness compensator **20520**. For example, referring to FIG. **70**, the coiled fibers **20586** can comprise a longitudinal axis between a first end **20587** and a second end **20589** of the coiled fiber **20586**. The longitudinal axes of the coiled fibers **20520** in the tissue thickness compensator **20520** can be parallel or substantially parallel. In some embodiments, the first end **20587** of each coiled fiber **20520** can be positioned along a first longitudinal side **20523** of the tissue thickness compensator **20520** and the second end **20589** of each coiled fiber **20586** can be positioned along a second longitudinal side **20524** of the tissue thickness compensator **20520**. In such an arrangement, the coiled fibers **20586** can laterally traverse the tissue thickness compensator. In other embodiments, the coiled fibers **20586** can longitudinally or diagonally traverse the tissue thickness compensator **20520**.

In various embodiments, similar to the crimped fibers **20086** described herein, the coiled fibers **20586** can comprise a polymeric composition. The crimped fibers **20586** can be at least partially elastic such that deformation of the crimped fibers **20586** generates a restoring force. In some embodiments, the polymeric composition of the coiled fibers **20586** can comprise polycaprolactone (PCL), for example, such that the coiled fibers **20586** are not soluble in a chlorophyll solvent. Referring to FIG. **70**A, the springs or coiled fibers **20520** can be retained in a compensation material **20580**. In various embodiments, the compensation material **20580** can hold the coiled fibers **20586** in a loaded position such that the coiled fibers **20586** exert a spring load on, or within, the compensation material **20580**. In certain embodiments, the compensation material **20580** can hold the coiled fibers **20586** in a neutral position where the coiled fibers **20586** are not exerting a spring load on, or within, the compensation material **20580**. The compensation material **20580** can be bioabsorbable and, in some embodiments, can comprise a foam, such as, for example, polyglycolic acid (PGA) foam. Furthermore, the compensation material **20580** can be soluble in a chlorophyll solvent, for example. In some embodiments the tissue thickness compensator can comprise coiled fibers **20586** that comprise polycaprolactone (PCL) and compensation material **20580** that comprises polyglycolic acid (PGA) foam, for example, such that the coiled fibers **20520** are not soluble in a chlorophyll solvent while the compensation material **20580** is soluble in the chlorophyll solvent. In various embodiments, the compensation material **20580** can be at least partially elastic, such that compression of the compensation material **20580** generates a restoring force. Further, similar to the embodiments described herein, referring to FIG. **70**B, the compensation material **20580** of the tissue thickness compensator **20520** can comprise a therapeutic agent **20588**, such as stem cells, for example. The compensation material **20580** can release a therapeutically effective amount of the therapeutic agent **20588** as the compensation material **20580** is absorbed.

Similar to the tissue thickness compensator **20020** described herein, the tissue thickness compensator **20520** can be compressible. For example, as staples **20030** (FIGS. **78-81**) are deployed from an initial position to a fired position, the staples **20030** can engage a portion of tissue thickness compensator **20520**. In various embodiments, a staple **20030** can capture a portion of the tissue thickness compensator **20520** and adjacent tissue T. The staple **20030** can apply a compressive force to the captured portion of the tissue thickness compensator **20520** and tissue T such that the tissue thickness compensator **20520** is compressed from a non-compressed height to a compressed height. Similar to the embodiments described herein, compression of the tissue thickness compensator **20520** can result in a corresponding deformation of the coiled fibers **20586** therein. As described in greater detail herein, deformation of each coiled fiber **20586** can generate a restoring force that can depend on the resiliency of the coiled fiber, for example, the amount the coiled fiber **20586** is deformed and/or the spring rate of the coiled fiber **20586**. The spring rate of the coiled fiber **20586** can at least depend on the orientation, material, shape and/or size of the coiled fiber **20586**, for example. Deformation of the coiled fibers **20586** in the tissue thickness compensator **20520** can generate restoring forces throughout the tissue thickness compensator **20520**. Similar to the embodiments described herein, the tissue thickness compensator **20520** can exert the aggregate restoring force generated by the deformed coiled fibers **20586** and/or the resilient compensation material **20586** on the captured tissue T in the fired staples **20030**.

In some embodiments, primarily referring to FIGS. **71** and **72**, a tissue thickness compensator **20620** for an end effector **12** can comprise a plurality of spring coils **20686**. Similar to the crimped fibers **20086** and coiled fibers **20586** described herein, spring coils **20686** can be, for example, crimped, twisted, coiled, bent, crippled, spiraled, curled, and/or bowed within the tissue thickness compensator **20620**. In various embodiments, similar to the fibers and coils described herein, the spring coils **20686** can comprise a polymeric composition. Further, the spring coils **20686** can be at least partially elastic such that deformation of the spring coils **20686** generates a restoring force. The spring coils **20686** can comprise a first end **20687**, a second end **20689**, and a longitudinal axis therebetween. Referring to FIG. **71**, the first end **20686** of a spring coil **20686** can be positioned at or near a proximal end **20626** of the tissue thickness compensator and the second end **20689** of the same spring coil **20686** can be positioned at or near a distal end **20625** of the tissue thickness compensator **20620** such that the spring coil **20686** longitudinally traverses the tissue thickness compensator **20620**, for example. In other embodiments, the coiled fibers **20686** can laterally or diagonally traverse the tissue thickness compensator **20620**.

The tissue thickness compensator **20620** can comprise an outer film **20680** that at least partially surrounds at least one spring coil **20686**. In various embodiments, referring to FIG. **71**, the outer film **20680** can extend around the perimeter of multiple spring coils **20686** in the tissue thickness compensator **20620**. In other embodiments, the outer film **20680** can completely encapsulate the spring coils **20686** or at least one spring coil **20686** in the tissue thickness compensator **20620**. The outer film **20680** can retain the spring coils **20686** in the end effector **12**. In various embodiments, the outer film **20680** can hold the spring coils **20686** in a loaded position such that the spring coils **20686** generate a spring load and exert a springback force on the outer film **20680**. In other embodiments, the outer film **20680** can hold the spring coils **20686** in a neutral position. The tissue thickness compensator **20620** can also comprise a filling material **20624**. In some embodiments, the filling material **20624** can be retained within and/or around the spring coils **20686** by the outer film **20680**. In some embodiments, the filling material **20624** can comprise a therapeutic agent **20688**, similar to the therapeutic agents described herein. Further, the filling material **20624** can support the spring coils **20686** within the tissue thickness compensator **20620**. The filling material **20624** can be compressible and at least partially resilient, such that the filling material **20624** contributes to the springback or restoring force generated by the tissue thickness compensator **20620**, as described in greater detail herein.

Similar to the tissue thickness compensators described herein, the tissue thickness compensator **20620** can be compressible. As staples **20030** (FIGS. **78-81**) are deployed from an initial position to a fired position, in various embodiments, the staples **20030** can engage a portion of the tissue thickness compensator **20620**. In various embodiments, each staple **20030** can capture a portion of the tissue thickness compensator **20620** along with adjacent tissue T. The staple **20030** can apply a compressive force to the captured portion of the tissue thickness compensator **20620** and the captured tissue T such that the tissue thickness compensator **20620** is compressed between a non-compressed height and a compressed height. Similar to the embodiments described herein, compression of the tissue thickness compensator **20620** can result in a corresponding deformation of the spring coils **20686** retained therein (FIG. **72**). As described in greater detail herein, deformation of each spring coils **20686** can generate a restoring force that depends on the resiliency of the spring coil **20686**, for example, the amount the spring coil **20686** is deformed and/or the spring rate of the spring coil **20686**. The spring rate of a spring coil **20686** can at least depend on the material, shape and/or dimensions of the spring coil **20686**, for example. Furthermore, depending on the resiliency of the filling material **20624** and the outer film **20680**, compression of the filling material **20624** and/or the outer film **20680** can also generate restoring forces. The aggregate of restoring forces generated at least by the deformed spring coils **20686**, the filling material **20624** and/or the outer film **20680** in the tissue thickness compensator **20620** can generate restoring forces throughout the tissue thickness compensator **20620**. Similar to the embodiments described herein, the tissue thickness compensator **20620** can exert the aggregate restoring force generated by the deformed spring coils **20686** on the captured tissue T in a fired staple **20030**.

In various embodiments, primarily referring to FIGS. **73-75**, a tissue thickness compensator **20720** for an end effector **12** can comprise a plurality of spring coils **20786**. Similar to the coiled fibers and springs described herein, spring coils **20786** can be, for example, crimped, twisted, coiled, bent, crippled, spiraled, curled, and/or bowed within the tissue thickness compensator **20720**. The spring coils **20786** can be at least partially elastic such that deformation of the spring coils **20786** generates a restoring force. Further, the spring coils **20786** can comprise a first end **20787**, a second end **20789**, and a longitudinal axis therebetween. Referring primarily to FIG. **75**, the first end **20787** of the spring coil **20786** can be positioned at or near a proximal end **20726** of the tissue thickness compensator **20720** and the second end **20789** of the spring coil **20786** can be positioned at or near a distal end **20725** of the tissue thickness compensator **20720** such that the spring coil **20786** longitudinally traverses the tissue thickness compensator **20720**. In some embodiments, the spring coil **20786** can longitudinally extend in two parallel rows in the tissue thickness compensator **20720**. The tissue thickness compensator **20720** can be positioned in an end effector **12** such that a sled **20050** (FIG. **61**) or cutting element **20052** can translate along a slot **20015** between the parallel rows of spring coils **20786**. In other embodiments, similar to various embodiments described herein, the spring coils **20786** can laterally or diagonally traverse the tissue thickness compensator **20720**.

Referring again to FIG. **75**, the spring coils **20786** can be retained or embedded in a compensation material **20780**. The compensation material **20780** can be bioabsorbable and, in some embodiments, can comprise foam, such as, for example, polyglycolic acid (PGA) foam. In various embodiments, the compensation material **20780** can be resilient such that deformation of the compensation material **20780** generates a springback force. The compensation material **20780** can be soluble in a chlorophyll solvent, for example. In some embodiments, for example, the tissue thickness compensator can comprise spring coils **20786** that comprise polycaprolactone (PCL) and compensation material **20780** that comprises polyglycolic acid (PGA) foam such that the spring coils **20786** are not soluble in a chlorophyll solvent while the compensation material **20780** is soluble in a chlorophyll solvent, for example. The compensation material **20780** can be at least partially resilient such that deformation of the compensation material **20780** generates a spring load or restoring force.

In various embodiments, the tissue thickness compensator **20720** can comprise interwoven threads **20790**, which can extend between parallel rows of spring coils **20786**. For example, referring to FIG. **75**, a first interwoven thread **20790** can diagonally traverse the two parallel rows of spring coils **20786** and a second interwoven thread **20790** can also diagonally traverse the two parallel rows of spring coils **20786**. In some embodiments, the first and second interwoven threads **20790** can crisscross. In various embodiments, the interwoven threads **20790** can crisscross multiple times along the length of the tissue thickness compensator **20720**. The interwoven threads **20790** can hold the spring coils **20786** in a loaded configuration such that the spring coils **20786** are held in a substantially flat position in the tissue thickness compensator **20720**. In some embodiments, the interwoven threads **20790** that traverse the tissue thickness compensator **20720** can be directly attached to the spring coils **20786**. In other embodiments, the interwoven threads **20790** can be coupled to the spring coils **20786** via a support **20792** that extends through each spring coil **20786** along the longitudinal axis thereof.

As described in greater detail herein, in various embodiments, a staple cartridge **20000** can comprise a slot **20015** configured to receive a translating sled **20050** comprising a cutting element **20052** (FIG. **61**). As the sled **20050** translates along the slot **20015**, the sled **20050** can eject staples **20030** from fastener cavities **20012** in the staple cartridge **20000** and the cutting element **20052** can simultaneously or nearly simultaneously sever tissue T. In various embodiments, referring again to FIG. **75**, as the cutting element **20052** translates, it can also sever the interwoven threads **20790** that crisscross between the parallel rows of spring coils **20786** in the tissue thickness compensator **20720**. As the interwoven threads **20790** are severed, each spring coil **20786** can be released from its loaded configuration such that each spring coil **20786** reverts from the loaded, substantially flat position to an expanded position in the tissue thickness compensator **20720**. In various embodiments, when a spring coil **20786** is expanded, the compensation material **20780** surrounding the spring coil **20786** can also expand.

In various embodiments, as staples **20030** (FIGS. **78-81**) are deployed from an initial position to a fired position, the staples **20030** can engage a portion of the tissue thickness compensator **20720** and the tissue thickness compensator **20720** can expand, or attempt to expand, within the staples **20030** and can apply a compressive force to the tissue T. In various embodiments, at least one staple **20030** can capture a portion of the tissue thickness compensator **20720**, along with adjacent tissue T. The staple **20030** can apply a compressive force to the captured portion of the tissue thickness compensator **20720** and the captured tissue T, such that the tissue thickness compensator **20720** is compressed between a non-compressed height and a compressed height. Similar to the embodiments described herein, compression of the tissue thickness compensator **20720** can result in a corresponding deformation of the spring coils **20786** and compensation material **20780** retained therein. As described in greater detail herein, deformation of each spring coils **20786** can generate a restoring force that can depend on the resiliency of the spring coil, for example, the amount the spring coil **20786** is deformed and/or the spring rate of the spring coil **20786**. The spring rate of a spring coil **20786** can at least depend on the orientation, material, shape and/or size of the spring coil **20786**, for example. The aggregate of restoring forces generated by at least the deformed spring coils **20786** and/or the compensation material **30380** in the tissue thickness compensator **20720** can generate restoring forces throughout the tissue thickness compensator **20720**. Similar to the embodiments described herein, the tissue thickness compensator **20720** can exert the aggregate restoring force generated by the deformed spring coils **20786** in the tissue thickness compensator **20720** on the captured tissue T and fired staples **20030**.

In various embodiments, primarily referring to FIGS. **76** and **77**, a tissue thickness compensator **20820** for a surgical end effector **12** can comprise a spring coil **20886**. Similar to the fibers and coils described herein, spring coil **20886** can be, for example, crimped, twisted, coiled, bent, crippled, spiraled, curled, and/or bowed within the tissue thickness compensator **20820**. The spring coil **20886** can comprise a polymeric composition and can be at least partially elastic, such that deformation of the spring coil **20886** generates a spring-back force. Further, the spring coil **20886** can comprise a first end **20887** and a second end **20889**. Referring to FIG. **76**, the first end **20887** can be positioned at or near a proximal end **20826** of the tissue thickness compensator **20820** and the second end **20889** can be positioned at or near a distal end **20825** of the tissue thickness compensator **20820**. The spring coil **20886** can wind or meander from the proximal end **20825** to the distal end **20826** of the tissue thickness compensator **20820**.

Referring again to FIG. **76**, the spring coil **20886** can be retained or embedded in a compensation material **20880**. The compensation material **20880** can be bioabsorbable and, in some embodiments, can comprise a foam, such as, for example, polyglycolic acid (PGA) foam. The compensation material **20880** can be soluble in a chlorophyll solvent, for example. In some embodiments, the tissue thickness compensator can comprise spring coils **20886** comprising polycaprolactone (PCL) and compensation material **20880** comprising polyglycolic acid (PGA) foam, for example, such that the spring coil **20886** is not soluble in a chlorophyll solvent while the compensation material **20880** is soluble in a chlorophyll solvent. The compensation material **20880** can be at least partially resilient such that deformation of the compensation material **20880** generates a spring load or restoring force.

Similar to tissue thickness compensators described herein, for example, the tissue thickness compensator **20820** can be compressible. Compression of the tissue thickness compensator **20820** can result in a deformation of at least a portion of the spring coil **20886** retained or embedded in the compensation material **20880** of the tissue thickness compensator **20820**. As described in greater detail herein, deformation of the spring coil **20886** can generate restoring forces that can depend on the resiliency of the spring coil **20886**, the amount the spring coil **20886** is deformed, and/or the spring rate of the spring coil **20886**, for example. The aggregate of restoring forces generated by the deformed spring coil **20886** and/or deformed compensation material **20880** can generate restoring forces throughout the tissue thickness compensator **20820**. The tissue thickness compensator **20820** can exert the aggregate restoring force on the captured tissue T in the fired staples **20030**.

Referring now to FIG. **84**, a surgical end effector **12** can comprise a tissue thickness compensator **30020** having at least one tubular element **30080**. The tissue thickness compensator **30020** can be retained in the surgical end effector **12**. As described in greater detail herein, a fastener in the end effector **12** can be deployed such that the fastener moves to a fired position and deforms at least a portion of the tubular element **30080** in the tissue thickness compensator **30020**. The reader will appreciate that tissue thickness compensators comprising at least one tubular element as described herein can be installed in or otherwise engaged with a variety of surgical end effectors and that such embodiments are within the scope of the present disclosure.

In various embodiments, still referring to FIG. **84**, the tissue thickness compensator **30020** can be positioned relative to the anvil **30060** of the end effector **12**. In other embodiments, the tissue thickness compensator **30020** can be positioned relative to a fastener cartridge assembly, such as staple cartridge **30000**, of the end effector **12**. In various embodiments, the staple cartridge **30000** can be configured to fit in a cartridge channel **30072** of a jaw **30070** of the end effector **12**. For example, the tissue thickness compensator **30020** can be releasably secured to the staple cartridge **30000**. In at least one embodiment, the tubular element **30080** of the tissue thickness compensator **30020** can be positioned adjacent to a top deck surface **30011** of a rigid support portion **30010** of the staple cartridge **30000**. In various embodiments, the tubular element **30080** can be secured to the top deck surface **30011** by an adhesive or by a wrap, similar to at least one of the wraps described herein (e.g., FIG. **16**). In various embodiments, the tissue thickness compensator **30020** can be integral to an assembly comprises the staple cartridge **30000** such that the staple cartridge **30000** and the tissue thickness compensator **30020** are formed as a single unit construction. For example, the staple cartridge **30000** can comprise a first body portion, such as the rigid support portion **30010**, and a second body portion, such as the tissue thickness compensator **30020**, for example.

Referring to FIGS. **84-86**, the tubular element **30080** in the tissue thickness compensator **30020** can comprise an elongate portion **30082** having at least one lumen **30084** that extends at least partially therethrough. Referring primarily to FIG. **86**, the elongate portion **30082** of the tubular element **30080** can comprise woven or braided strands **30090**, as described in greater detail herein. In other embodiments, the elongate portion **30082** can comprise a solid structure, such as a polymer extrusion, rather than woven strands **30090**. The elongate portion **30082** of the tubular element **30080** can comprise a thickness. In various embodiments, the thickness of the elongate portion **30082** can be substantially uniform throughout the length and around the diameter thereof; in other embodiments, the thickness can vary. The elongate portion **30082** can be elongated such that the length of the elongate portion **30082** is greater than the diameter of the elongate portion **30082**, for example. In various embodiments, the elongate portion can comprise a length of approximately 1.20 inches to approximately 2.60 inches and a diameter of approximately 0.10 inches to approximately 0.15 inches, for example. In some embodiments, the length of the tubular element **20080** can be approximately 1.40 inches, for example, and the diameter of the tubular element **20080** can be approximately 0.125 inches, for example. Furthermore, the elongate portion **30082** can define a substantially circular or elliptical cross-sectional shape, for example. In other embodiments, the cross-sectional shape can comprise a polygonal shape, such as, for example, a triangle, a hexagon and/or an octagon. Referring again to FIG. **84**, the tubular element **30080** can comprise a first distal end **30083** and a second proximal end **30085**. In various embodiments, the cross-sectional shape of the elongate portion **30082** can narrow at the first and/or second end **30083**, **30085** wherein at least one end **30083**, **30085** of the tubular element **30080** can be closed and/or sealed. In other embodiments, a lumen **30084** can continue through the distal ends **30083**, **30085** of the tubular element **30080** such that the ends **30083**, **30085** are open.

In various embodiments, the tubular element **30080** can comprise a single central lumen **30084** that extends at least partially through the elongate portion **30084**. In some embodiments, the lumen **30084** can extend through the entire length of the elongate portion **30084**. In still other embodiments, the tubular element **30080** can comprise multiple lumens **30084** extending therethrough. Lumens **30084** extending through the tubular element **30080** can be circular, semi-circular, wedge-shaped, and/or combinations thereof. In various embodiments, a tubular element **30080** can also comprise support webs that can form a modified "T" or "X" shape, for example, within the lumen **30084**. In various embodiments, the dimensions, lumen(s), and/or support web(s) within the tubular element **30080** can define the cross-sectional shape of the tubular element **30080**. The cross-sectional shape of the tubular element **30080** can be consistent throughout the length thereof or, in other embodiments, the cross-sectional shape of the tubular element **30080** can vary along the length thereof. As described in greater detail herein, the cross-sectional shape of the tubular element **30080** can affect the compressibility and resiliency of the tubular element **30080**.

In various embodiments, the tubular element **30080** can comprise a vertical diameter and a horizontal diameter; the dimensions thereof can be selected depending on the arrangement of the tubular element **30080** in the end effector **12**, the dimensions of the end effector **12**, including the tissue gap of the end effector **12**, and the expected geometry of the staple entrapment areas **30039**. For example, the vertical diameter of the tubular element **30080** can relate to the expected height of a formed staple. In such embodiments, the vertical diameter of the tubular element **30080** can be selected such that the vertical diameter can be reduced approximately 5% to approximately 20% when the tubular element **30080** is captured within a formed staple **30030**. For example, a tubular element **30080** having a vertical diameter of approximately 0.100 inches may be used for staples having an expected formed height of approximately 0.080 inches to approximately 0.095 inches. As a result, the vertical diameter of the tubular element **30080** can be reduced approximately 5% to approximately 20% when captured within the formed staple **30030** even when no tissue T is captured therein. When tissue T is captured within the formed staple **30030**, the compression of the tubular element **30080** may be even greater. In some embodiments, the vertical diameter can be uniform throughout the length of the tubular element **30080** or, in other embodiments, the vertical diameter can vary along the length thereof.

In some embodiments, the horizontal diameter of the tubular element **30080** can be greater than, equal to, or less than the vertical diameter of the tubular element **30080** when the tubular element **30080** is in an undeformed or rebounded configuration. For example, referring to FIG. **85**, the horizontal diameter can be approximately three times larger than the vertical diameter, for example. In some embodiments the horizontal diameter can be approximately 0.400 inches and the vertical diameter can be approximately 0.125 inches, for example. In other embodiments, referring now to FIG. **87**, the horizontal diameter of a tubular element **31080** can be equal to or substantially equal to the vertical diameter of the tubular element **31080** when the tubular element **31080** is in an undeformed or rebounded configuration. In some embodiments the horizontal diameter can be approximately 0.125 inches and the vertical diameter can also be approximately 0.125 inches, for example. In various embodiments, the tubular element **30080** can comprise a vertical diameter of approximately 0.125 inches, a horizontal diameter of approximately 0.400 inches, and a length of approximately 1.400 inches. As described in greater detail herein, when a force A is applied to the tubular element **30080** and/or **31080**, the tubular element can deform such that the cross-sectional geometry, including the horizontal and vertical diameters, can change.

Referring again to FIGS. **84-86**, the tubular element **30080** in the tissue thickness compensator **30020** can be deformable. In various embodiments, the entire tubular element **30080** can be deformable. For example, the tubular element **30080** can be deformable from the proximal end **30083** to the distal end **30085** of the elongate portion **30082** and around the entire circumference thereof. In other embodiments, only a portion of the tubular element **30080** can be deformable. For example, in various embodiments, only an intermediate length of the elongate portion **30082** and/or only a portion of the circumference of the tubular element **30080** can be deformable.

When a compressive force is applied to a contact point on the elongate portion **30082** of the tubular element **30080**, the contact point can shift, which can alter the cross-sectional dimensions of the tubular element **30080**. For example, referring again to FIG. **85**, the tubular element **30080** can comprise a top apex **30086** and a bottom apex **30088** on the elongate portion **30082**. In the initial, undeformed configuration, the tubular element **30080** can comprise undeformed cross-sectional dimensions, including an undeformed vertical diameter between the top apex **30086** and the bottom apex **30088**. When a compressive force A is applied to the top apex **30086**, the tubular element **30080** can move to a deformed configuration. In the deformed configuration, the cross-sectional dimensions of the tube **30080** can be altered. For example, the tube **30086** can comprise a deformed vertical diameter between the top apex **30086** and the bottom apex **30088**, which can be less than the undeformed vertical diameter. In some embodiments, referring to FIG. **87**, the horizontal diameter of the deformed tube **30080** can be lengthened, for example, when the tubular element **30080** moves from an undeformed configuration to a deformed configuration. The deformed cross-sectional dimensions of the deformed tube **30080** can at least depend on the position, angular orientation, and/or magnitude of the applied force A. As described in greater detail herein, deformation of a tubular element **30080** can generate a springback or restoring force that can depend on the resiliency of the tubular element **30080**.

Referring still to FIG. **85**, the tubular element **30080** can generate a springback or restoring force when compressed. In such embodiments, as described herein, the tubular element **30080** can move from an initial undeformed configuration to a deformed configuration when a force A is applied to a contact point on the elongate portion **30082** of the tubular element **30080**. When the applied force A is removed, the deformed tube **30080** can rebound from the deformed configuration. The deformed tube **30080** may rebound to the initial, undeformed configuration or may rebound to a configuration substantially similar to the initial, undeformed configuration. The ability of the tubular element **30080** to rebound from a deformed configuration relates to the resiliency of the tubular element **30080**.

Referring again to FIG. **85**, a tubular element **30080** can exert a springback or restoring force. The restoring force can be generated by the tubular element **30080** when an applied force A is exerted on the tubular element **30080**, for example, by a staple **30030** (FIGS. **88** and **89**), as described in greater detail herein. An applied force A can alter the cross-sectional dimensions of the tubular element **30080**. Furthermore, in linear-elastic materials, the restoring force of each deformed portion of the tubular element **30080** can be a function of the deformed dimensions of the tubular element **30080** and the spring rate of that portion of the tubular element **30080**. The spring rate of a tubular element **30080** can at least depend on the orientation, material, cross-sectional geometry and/or dimensions of the tubular element **30080**, for example. In various embodiments, the tubular element **30080** in a tissue thickness compensator **30020** can comprise a uniform spring rate. In other embodiments, the spring rate can vary along the length and/or around the diameter of the tubular element **30080**. When a portion of a tubular element **30080** having a first spring rate is greatly compressed, the tubular element **30080** can generate a large restoring force. When a portion of the tubular element **30080** having the same first spring rate is less compressed, the tubular element **30080** can generate a smaller restoring force.

Referring again to FIG. **84**, the tubular element **30080** in the tissue thickness compensator **30020** can comprise a polymeric composition. In some embodiments, the elongate portion **30082** of the tubular element **30080** can comprise the polymeric composition. Further, in various embodiments, the polymeric composition can comprise an at least partially elastic material such that deformation of the tubular element **30080** generates a restoring force. The polymeric composition can comprise non-absorbable polymers, absorbable polymers, or combinations thereof, for example. Examples of synthetic polymers include, but are not limited to, polyglycolic acid (PGA), poly(lactic acid) (PLA), polycaprolactone (PCL), polydioxanone (PDO), and copolymers thereof. In some embodiments, the absorbable polymers can include bioabsorbable, biocompatible elastomeric polymers, for example. Furthermore, the polymeric composition of the tubular element **30080** can comprise synthetic polymers, non-synthetic polymers, or combinations thereof, for example. In various embodiments, similar to the polymeric compositions in embodiments described herein, the polymeric composition of the tubular element **30080** can include varied amounts of absorbable polymers, non-absorbable polymers, synthetic polymers, and/or non-synthetic polymers, for example, by weight percentage.

Referring to FIGS. **84** and **85**, the tubular element **30080** can comprise a therapeutic agent **30098** such as a pharmaceutically active agent or medicament, for example. In various embodiments, the therapeutic agent **30098** can be retained in the lumen **30084** of the tubular element **30080**. The elongate portion **30082** can encapsulate or partially encapsulate the therapeutic agent **30098**. Additionally or alternatively, the polymeric composition of the elongate portion **30082** can comprise the therapeutic agent **30098**. The tubular element **30080** can release a therapeutically effective amount of the therapeutic agent **30098**. In various embodiments, the therapeutic agent **30098** can be released as the tubular element **30080** is absorbed. For example, the therapeutic agent **30098** can be released into fluid (such as blood) passing over or through the tubular element **30080**. In still other embodiments, the therapeutic agent **30098** can be released when a staple **30030** (FIGS. **88** and **89**) pierces the tubular element **30080** and/or when the cutting element **30052** on the staple-firing sled **30050** (FIG. **84**) cuts a portion of the tubular element **30080**, for example. Examples of therapeutic agents **30098** can include, but are not limited to, haemostatic agents and drugs such as, for example, fibrin, thrombin, and/or oxidized regenerated cellulose (ORC), anti-inflammatory drugs such as, for example, diclofenac, aspirin, naproxen, sulindac, and/or hydrocortisone, antibiotic and antimicrobial drugs or agents such as, for example, triclosan, ionic silver, ampicillin, gentamicin, polymyxin B, and/or chloramphenicol, anticancer agents such as, for example, cisplatin, mitomycin, and/or adriamycin, and/or biologics such as, for example, stem cells.

In various embodiments, referring again to FIGS. **84**, **88** and **89**, fasteners such as staples **30030**, for example, can be deployed from a staple cartridge **30000** such that the staples **30030** engage a tissue thickness compensator **30020** and apply a force A to a tubular element **32080** therein. As described herein, application of a force A to the tubular element **30080** can cause deformation of the tubular element **30080**. Similar to the end effectors **12** described herein, the rigid support portion **30010** of the staple cartridge **30000** can comprise a cartridge body **30017**, a deck surface **30011**, and a plurality of staple cavities **30012** therein. Each staple cavity **30012** can define an opening in the deck surface **30011** and a staple **30030** can be removably positioned in a staple cavity **30012** (FIG. **104**). In at least one embodiment, referring primarily to FIGS. **88** and **89**, each staple **30030** can comprise a base **30031** and two staple legs **30032** extending from the base **30031**. Prior to the deployment of the staples **30030**, the base **30031** of each staple **30030** can be supported by a staple driver **30040** (FIG. **104**) positioned within the rigid support portion **30010** of the staple cartridge **30000**. Also prior to the deployment of the staples **30030**, the legs **30032** of each staple **30030** can be at least partially contained within the staple cavity **30012** (FIG. **104**).

In various embodiments, as described in greater detail herein, the staples **30030** can be deployed between an initial position and a fired position. For example, a staple-firing sled **30050** can engage a driver **30040** (FIG. **104**) to move at least one staple **30030** between the initial position and the fired position. In various embodiments, referring primarily to FIG. **88**, the staple **30030** can be moved to a fired position, wherein the legs **30032** of the staple **30030** engage a tubular element **32080** of a tissue thickness compensator **32020**, penetrate tissue T, and contact an anvil **30060** (FIG. **104**) positioned opposite the staple cartridge **30000** in the surgical end effector **12**. Staple forming pockets **30062** in the anvil **30060** can bend the staple legs **30032** such that the fired staple **30030** captures a portion of the tubular element **32080** and a portion of the tissue T in a staple entrapment area **30039**. As described in greater detail herein, at least one staple leg **30032** can pierce the tubular element **32080** of the tissue thickness compensator **32020** when the staple **30030** moves between the initial position and the fired position. In other embodiments, the staple legs **30032** can move around the perimeter of the tubular element **32080** such that the staple legs **30032** avoid piercing the tubular element **32080**. Similar to the fasteners described herein, the legs **30032** of each staple **30030** can be deformed downwardly toward the base **30031** of the staple **30030** to form a staple entrapment area **30039** therebetween. The staple entrapment area **30039** can be the area in which tissue T and a portion of the tissue thickness compensator **32020** can be captured by a fired staple **30030**. In the fired position, each staple **30030** can apply a compressive force to the tissue T and to the tissue thickness compensator **32020** captured within the staple entrapment area **30039** of the staple **30030**.

In various embodiments, referring still to FIG. **88**, when the tubular element **32080** is captured in a staple entrapment area **30039**, the captured portion of the tubular element **32080** can be deformed, as described herein. Furthermore, the tubular element **32080** can be deformed to different deformed configurations in different staple entrapment areas **30039** depending on, for example, the thickness, compressibility, and/or density of the tissue T captured in that same staple entrapment area **30039**. In various embodiments, the tubular element **32080** in the tissue thickness compensator **32080** can extend longitudinally through successive staple entrapment areas **30039**. In such an arrangement, the tubular element **32080** can be deformed to different deformed configurations in each staple entrapment area **30039** along a row of fired staples **30030**. Referring now to FIG. **89**, tubular elements **33080** in a tissue thickness compensator **33020** can be laterally arranged in the staple entrapment areas **30039** along a row of fired staples **30030**. In various embodiments, the tubular elements **33080** can be retained by a flexible shell **33210**. In such arrangements, the tubular elements **33080** and flexible shell **33210** can be deformed to different deformed configurations in each staple entrapment area **30039**. For example, where the tissue T is thinner, the tubular elements **33080** can be compressed less and where the tissue T is thicker, the tubular elements **33080** can be compressed more to accommodate the thicker tissue T. In other embodiments, the deformed dimensions of the tubular elements **33080** can be uniform throughout the entire length and/or width of the tissue thickness compensator **33020**.

Referring to FIGS. **90-92**, in various embodiments, a tubular element **34080** in a tissue thickness compensator **34020** can comprise a plurality of strands **34090**. Referring primarily to FIG. **90**, in some embodiments, the strands **34090** can be woven or braided into a tubular lattice **34092** forming the tubular element **34080**. The tubular lattice **34092** formed by the strands **34090** can be substantially hollow. The strands **34090** of the tubular element **34080** can be solid strands, tubular strands, and/or another other suitable shape. For example, referring to FIG. **91**, a single strand **34090** of the tubular lattice **34092** can be a tube. In various embodiments, referring to FIG. **93**, a strand **34090** can comprise at least one lumen **34094** extending therethrough. The number, geometry and/or dimensions(s) of the lumens **34094** can determine the cross-sectional shape of the strand **34090**. For example, a strand **34090** can comprise circular lumen(s), semi-circular lumen(s), wedge-shaped lumen(s), and/or combinations thereof. In various embodiments, a strand **34090** can also comprise support webs **34096** that can form a modified "T" or "X" shape, for example. At least the diameter of the strand **34090**, the lumen(s) extending therethrough, and the support web(s) can characterize the cross-sectional shape of a strand **34090**. The cross-sectional shape of each strand **34090**, as discussed in greater detail herein, can affect the springback or restoring force generated by the strand **34090** and the corresponding springback or restoring force generated by the tubular element **34080**.

Referring to FIG. **94**, a tubular lattice **34092** of strands **34090** can be deformable. In various embodiments, the tubular lattice **34092** can produce or contribute to the deformability and/or the resiliency of the tubular element **34080**. For example, the strands **34090** of the tubular lattice **34092** can be woven together such that the strands **34090** are configured to slide and/or bend relative to each other. When a force is applied to the elongate portion **34082** of the tubular element **34080**, the strands **34090** therein may slide and/or bend such that the tubular lattice **34092** moves to a deformed configuration. For example, referring still to FIG. **94**, a staple **30030** can compress the tubular lattice **34092** and the tissue T captured in a staple entrapment area **34039** which can cause the strands **34090** of the tubular lattice **34092** to slide and/or bend relative to each other. A top apex **34086** of the tubular lattice **34092** can move towards a bottom apex **34088** of the tubular lattice **34092** when the tubular lattice **34092** is compressed to the deformed configuration in order to accommodate the captured tissue T in a staple entrapment area **30039**. In various circumstances, the tubular lattice **34092** captured in a fired stapled **30030** will seek to regain its undeformed configuration and can apply a restoring force to the captured tissue T. Further, the portions of the tubular lattice **34092** positioned between staple entrapment areas **30039**, i.e., not captured within a fired staple **30030**, can also be deformed due to the deformation of adjacent portions of the tubular lattice **34092** that are within the staple entrapment areas **30039**. Where the tubular lattice **34092** is deformed, the tubular lattice **34092** can seek to rebound or partially rebound from the deformed configuration. In various embodiments, portions of the tubular lattice **34092** can rebound to their initial configurations and other portions of the tubular lattice **34092** can only partially rebound and/or remain fully compressed.

Similar to the description of the tubular elements herein, each strand **34090** can also be deformable. Further, deformation of a strand **34090** can generate a restoring force that depends on the resiliency of each strand **34090**. In some embodiments, referring primarily to FIGS. **91** and **92**, each strand **34090** of a tubular lattice **34092** can be tubular. In other embodiments, each strand **34090** of a tubular lattice **34092** can be solid. In still other embodiments, the tubular lattice **30092** can comprise at least one tubular strand **34090**, at least one solid strand **34090**, at least one "X"- or "T"-shaped strand **34090**, and/or a combination thereof.

In various embodiments, the strands **34090** in the tubular element **34080** can comprise a polymeric composition. The polymeric composition of a strand **34090** can comprise non-absorbable polymers, absorbable polymers, or combinations thereof. Examples of synthetic polymers include, but are not limited to, polyglycolic acid (PGA), poly(lactic acid) (PLA), polycaprolactone (PCL), polydioxanone (PDO), and copolymers thereof. In some embodiments, the absorbable polymers can include bioabsorbable, biocompatible elastomeric polymers, for example. Furthermore, the polymeric composition of the strand **34090** can comprise synthetic polymers, non-synthetic polymers, and/or combinations thereof. In various embodiments, similar to the polymeric compositions in embodiments described herein, the polymeric composition of the strand **34090** can include varied amounts of absorbable polymers, non-absorbable polymers, synthetic polymers, and/or non-synthetic polymers, for example, by weight percentage.

The strands **34090** in the tubular element **34080** can further comprise a therapeutic agent **34098** (FIG. **91**) such as a pharmaceutically active agent or medicament, for example. In some embodiments, the strand **34090** can release a therapeutically effective amount of the therapeutic agent **34098**. In various embodiments, the therapeutic agent **34098** can be released as the tubular strand **34090** is absorbed. For example, the therapeutic agent **30098** can be released into fluid, such as blood for example, passing over or through the strand **34090**. In still other embodiments, the therapeutic agent **34098** can be released when a staple **30030** pierces the strand **34090** and/or when the cutting element **30052** on the staple-firing sled **30050** (FIG. **84**) cuts a portion of the tubular lattice **34092**, for example. Examples of therapeutic agents **34098** can include, but are not limited to, haemostatic agents and drugs such as, for example, fibrin, thrombin, and/or oxidized regenerated cellulose (ORC), anti-inflammatory drugs such as, for example, diclofenac, aspirin, naproxen, sulindac, and/or hydrocortisone, antibiotic and antimicrobial drugs or agents such as, for example, triclosan, ionic silver, ampicillin, gentamicin, polymyxin B, and/or chloramphenicol, anticancer agents such as, for example, cisplatin, mitomycin, and/or adriamycin; and/or biologics such as, for example, stem cells.

Referring to FIGS. **95** and **96**, a tubular element **35080** can comprise multiple layers **35100** of strands **35090**. In some embodiments, the tubular element **35080** can comprise multiple layers **35100** of tubular lattices **35092**. Referring to FIG. **95**, the tubular element **35080** can comprise a first layer **35100*a*** and a second layer **35100*b*** of strands **35090**, for example. Referring now to FIG. **96**, a tubular element **35180** of a tissue thickness compensator **35120** can comprise a third layer **35100*c*** of strands **35090**, for example. Furthermore, different layers **35100** in the tubular element **35180** can comprise different materials. In some embodiments, each layer **35100*a***, **35100*b***, **35100*c*** can be bioabsorbable, wherein, in at least one embodiment, each layer **35100*a***, **35100*b***, **35100*c*** can comprise a different polymeric composition. For example, the first layer **35100*a*** can comprise a first polymeric composition; the second layer **35100*b*** can comprise a second polymeric composition; and the third layer **35100*c*** can comprise a third polymeric composition. In such embodiments, layers **35100*a***, **35100*b***, **35100*c*** of the tubular element **35180** can be bioabsorbed at different rates. For example, the first layer **35100*a*** can absorb quickly, the second layer **35100*b*** can absorb slower than the first layer **35100*a***, and the third layer **35100*c*** can absorb slower than the first layer **35100*a*** and/or the second layer **35100*b***. In other embodiments, the first layer **35100*a*** can absorb slowly, the second layer **35100*b*** can absorb faster than the first layer **35100*a***, and the third layer **35100*c*** can absorb faster than the first layer **35100*a*** and/or the second layer **35100*b***.

Similar to strands **34090** described herein, the strands **35090** in the tubular element **35180** can comprise a medicament **35098**. In various embodiments, referring again to FIG. **95**, to control elusion or release of the medicament(s) **35098**, the first layer **35100*a*** of strands **35090** comprising a medicament **35098*a*** can be bioabsorbed at a first rate and the second layer **35100*b*** of strands **35090** comprising a medicament **30098*b*** can be bioabsorbed at a second rate. For example, the first layer **35100*a*** can absorb quickly to allow for a rapid initial release of the medicament **35098*a*** and the second layer **35100*b*** can absorb slower to allow controlled release of the medicament **30098*b***. The medicament **35098*a*** in the strands **35090** of the first layer **30100*a*** can be different than the medicament **35098*b*** in the strands **35090** of the second layer **35100*b***. For example, the strands **35090** in the first layer **35100*a*** can comprise oxidized regenerated cellulose (ORC) and the strands **35090** in the second layer **35100*b*** can comprise a solution comprising hyaluronic acid. In such embodiments, initial absorption of the first layer **35100*a*** can release oxidized regenerated cellulose to help control bleeding while subsequent absorption of the second layer **35100*b*** can release a solution comprising hyaluronic acid to can help prevent the adhesion of tissue. In other embodiments, the layers **35100*a***, **35100*b*** can comprise the same medicament **35098*a***, **35098*b***. For example, referring again to FIG. **96**, strands **35090** in layers **35100*a***, **35100*b*** and **35100*c*** can comprise an anticancer agent, such as, for example, cisplatin. Furthermore, the first layer **35100*a*** can absorb quickly to allow for a rapid initial release of cisplatin, the second layer **35100*b*** can absorb slower to allow for a controlled release of cisplatin, and the third layer **35100*c*** can absorb slowest to allow for a more extended, controlled release of cisplatin.

In various embodiments, referring to FIGS. **97** and **98**, a tissue thickness compensator **36020** can comprise an overmold material **36024**. The overmold material **36024** can be formed outside a tubular element **36080**, inside a tubular element **36080**, or both inside and outside a tubular element **36080**. In some embodiments, referring to FIG. **97**, the overmold material **36024** can be coextruded both inside and outside the tubular element **36080** and, in at least one embodiment, the tubular element **36080** can comprise a tubular lattice **36092** of strands **36090**. Similar to the polymeric composition described herein, the overmold material **36024** can comprise polyglycolic acid (PGA), poly(lactic acid) (PLA), and/or any other suitable, bioabsorbable and biocompatible elastomeric polymers, for example. Further, the overmold material **36024** can be non-porous such that the overmold material **36024** forms a fluid-impervious layer in the tubular element **36080**. In various embodiments, the overmold material **36024** can define a lumen **36084** therethrough.

Further to the discussion above, the tubular element **36080** and/or the strands **36090** in a tubular lattice **36092** can comprise a therapeutic agent **36098**. In some embodiments, referring still to FIGS. **97** and **98**, a non-porous overmold material **36024** can contain the medicament **36098** within an inner lumen **36084*a***. Alternatively or additionally, the non-porous, overmold material **36024** can contain the medicament **36098** within an intermediate lumen **36084*b***, such as, for example, the intermediate lumen **36084*b*** that contains the tubular lattice **36092** of medicament-comprising strands **36090**. Similar to the above, the tubular element **36080** can be positioned relative to staple cavities **30012** and a cutting element **30052** in staple cartridge **30000** (FIG. **84**). In several such embodiments, the deployment of the staples **30030** and/or the translation of the cutting element **30052** can be configured to pierce or rupture the non-porous, overmold material **36024** such that the medicament **36098** contained in at least one lumen **36084** of the tubular element **30080** can be released from the lumen **30084**. In various embodiments, referring to FIG. **99**, a tubular element **37080** can comprise a non-porous film **37110**. The non-porous film **37110** can at least partially surround a tubular lattice **37092** or a first layer **37100*a*** and a second layer **37100*b*** of tubular lattices **30092** to provide a fluid-impervious cover similar to the overmold material **36024** described herein.

As described herein, a tubular element can comprise at least one of a bioabsorbable material, a therapeutic agent, a plurality of strands, a tubular lattice, layers of tubular lattices, an overmold material, a non-porous film, or combinations thereof. For example, referring to FIG. FIG. **100**, a tubular element **38080** can comprise an overmold material **38024** and a plurality of strands **38090** positioned through a central lumen **38084** of the tubular element **38080**. In some embodiments, the strands **38090** can comprise a therapeutic agent **38098**. In other embodiments, for example, referring to FIG. **101**, a tubular element **39080** can comprise an overmold material **39024** and a therapeutic agent **39098** positioned in a central lumen **39084** of the tubular element **39080**, for example. In various embodiments, at least one of the tubular element **39080** and overmold material **39024** can comprise a fluidic therapeutic agent **39098**.

In various embodiments, referring again primarily FIG. **84**, the tubular element **30080** can be positioned relative to the rigid support portion **30010** of the staple cartridge **30000**. The tubular element **30080** can be longitudinally positioned adjacent to the rigid support portion **30010**. In some embodiments, the tubular element **30080** can be substantially parallel to or aligned with a longitudinal slot or cavity **30015** in the rigid support portion **30010**. The tubular element **30080** can be aligned with the longitudinal slot **30015** such that a portion of the tubular element **30080** overlaps a portion of the longitudinal slot **30015**. In such embodiments, a cutting element **30052** on the staple-firing sled **30050** can sever a portion of the tubular element **30080** as the cutting edge **30052** translates along the longitudinal slot **30015**. In other embodiments, the tubular element **30080** can be longitudinally positioned on a first or second side of the longitudinal slot **30015**. In still other embodiments, the tubular element **30080** can be positioned relative to the rigid support portion **30010** of the staple cartridge **30000** such that the tubular element **30080** laterally or diagonally traverses at least a portion of the rigid support portion **30010**.

In various embodiments, referring to FIG. **102** for example, a tissue thickness compensator **40020** can comprise multiple tubular elements **40080**. In some embodiments, the tubular elements **40080** can comprise different lengths, cross-sectional shapes, and/or materials, for example. Further, the tubular elements **40080** can be positioned relative to the rigid support portion **40010** of the staple cartridge **30000** such that the tubular axes of the tubular elements **40080** are parallel to each other. In some embodiments, the tubular axes of tubular elements **40080** can be longitudinally aligned such that a first tubular element **40080** is positioned within another tubular element **40080**. In other embodiments, parallel tubular elements **40080** can longitudinally traverse the staple cartridge **30000**, for example. In still other embodiments, parallel tubular elements **40080** can laterally or diagonally traverse the staple cartridge **30000**. In various other embodiments, non-parallel tubular elements **40080** can be angularly-oriented relative to each other such that their tubular axes intersect and/or are not parallel to each other.

Referring to FIGS. **102-105**, a tissue thickness compensator **40020** can have two tubular elements **40080**; a first tubular element **40080***a* can be longitudinally positioned on a first side of the longitudinal slot **30015** in the rigid support portion **30010** and a second tubular element **40080***b* can be longitudinally positioned on a second side of the longitudinal slot **30015**. Each tubular element **40080** can comprise a tubular lattice **40092** of strands **40090**. In various embodiments, the staple cartridge **30000** can comprise a total of six rows of staple cavities **30012**, wherein three rows of staple cavities **30012** are positioned on each side of the longitudinal slot **30015**, for example. In such embodiments, the cutting edge **30052** on the translating staple-firing sled **30050** may not be required to sever a portion of the tubular element **40080**.

Similarly, referring now to FIGS. **106-107**, a tissue thickness compensator **41020** can comprise two tubular elements **41080***a*, **41080***b* longitudinally arranged in the staple cartridge **30000**. Similar to the above, staples **30030** from three rows of staple cavities **30012** can engage one tubular element

41080*a* and staples **30030** from three different rows of staple cavities **30012** can engage another tubular element **41080***b*. In various embodiments, referring still to FIGS. **106-107**, deployed staples **30030** can engage the tubular element **40080** at different locations across the cross-section of the tubular element **40080**. As discussed herein, the springback resiliency and corresponding restoring force exerted by the tubular element **41080** can depend on the cross-sectional shape of the tubular element **41080**, among other things. In some embodiments, a staple **30030** positioned in a staple entrapment area **30039** located at or near an arced portion of the tubular element **41080** can experience a greater restoring force than a staple **30030** in a staple entrapment area **30039** positioned near a non-arced portion. Similarly, a staple **30030** positioned in staple entrapment area **30039** in the non-arced portion of the tubular element **41080** can experience a lesser restoring force than the restoring force experienced by a staple **30030** positioned at or nearer to the arced portion of the tubular element **30080**. In other words, the arced portions of a tubular element **41080** can have a greater spring rate than the non-arced portion of the tubular element **41080** owing to the possibility that a larger quantity of elastic material may be captured by the staples **30030** along such portions. In various embodiments, as a result, referring primarily to FIG. **107**, the restoring force generated by the tissue thickness compensator **41020** can be greater near staples **30030***a* and **30030***c* and less near staple **30030***b* in tubular element **30080***a*. Correspondingly, the restoring force generated by the tissue thickness compensator **41020** can be greater near staples **30030***d* and **30030***f* than near staple **30030***e* in tubular element **30080***b*.

Referring again to FIGS. **102-105**, in various embodiments, the cross-sectional geometries of strands **40090** comprising the tubular lattice **40092** can be selected in order to provide a desired springback resiliency and corresponding restoring force exerted by the tubular lattice **40092**. For example, referring again to FIG. **103**, strands **40090***a* positioned in arced portions of the tubular element **40080** can comprise X-shaped cross-sections, whereas strands **40090***b* positioned in non-arced portions of the tubular element **40080** can comprise tubular cross-sections. In some embodiments, strands **40090***a* and **40090***b* comprising different cross-sectional geometries can be woven together to form the tubular lattice **40092**. In other embodiments, the strands **40090***a* and **40090***b* can be attached to one another with an adhesive, for example. Referring to FIGS. **104** and **105**, the different cross-sectional geometries of strands **40090** in the tubular element **40080** can optimize the restoring force experienced in staple entrapment areas **30039** across the staple cartridge **30000**. In some embodiments, specific cross-sectional geometries can be selected such that the springback constant in staple entrapment areas **30039** across the staple cartridge is substantially balanced or equal.

In some embodiments, referring to FIG. **108**, the tubular elements **41080***a*, **41080***b* of a tissue thickness compensator **41120** can be fastened together by an adjoining portion **41126**. Though the translating cutting element **30052** can be configured to pass between tubular elements **41080***a* and **41080***b*, the cutting element **30052** can be required to sever at least a portion of the adjoining portion **41126**. In some embodiments, the adjoining portion **41126** can comprise a soft material, such as, for example, a foam or gel, which is easily severed by the translating cutting element **30052**. In various embodiments, the adjoining portion **41026** can releasably secure the tissue thickness compensator **41120** to the surgical end effector **12**. In at least one embodiment, the adjoining portion **41126** can be fixed to the top deck surface **30011** of the rigid support portion **30010** such that the adjoining portion **41126** remains retained in the surgical end effector **12** after the tubular elements **41080***a*, **41080***b* are released therefrom.

In various embodiments, referring to FIGS. **109-110**, a tissue thickness compensator **42020** can comprise multiple tubular elements **42080** such that the number of tubular elements **42080** is the same as the number of rows of staple cavities **30012** in the staple cartridge **30000**, for example. In at least one embodiment, the staple cartridge **30000** can comprise six rows of staple cavities **30012** and the tissue thickness compensator **42020** can comprise six tubular elements **42080**. Each tubular element **42080** can be substantially aligned with a row of staple cavities **30012**. When staples **30030** are ejected from a row of staple cavities **30012**, each staple **30030** from that row can pierce the same tubular element **42080** (FIG. **110**). In various embodiments, the deformation of one tube **42080** can have little or no impact on the deformation of an adjacent tube **42080**. Accordingly, the tubular elements **42080** can exert a substantially discrete and customized springback force in staple entrapment areas **30039** across the width of the staple cartridge **30030**. In some embodiments, where staples **30030** fired from multiple rows of staple cavities **30012** engage the same tubular element **35080** (FIG. **107**), the deformation of the tubular element **35080** can be less customized. For example, the deformation of a tubular element **35080** in a staple entrapment area **30039** in a first row can impact the deformation of that tubular element **35080** in staple entrapment area **30039** in another row. In at least one embodiment, the translating cutting edge **30052** can avoid severing the tubular elements **42080**. In other embodiments, referring to FIG. **111**, a tissue thickness compensator **43020** can comprise more than six tubular elements **43080**, such as, for example, seven tubular elements **44080**. Further, the tubular elements **43080** can be symmetrically or non-symmetrically arranged in the end effector **12**. When an odd number of tubular elements **43080** are longitudinally and symmetrically arranged in the end effector **12**, the translating cutting element **30052** can be configured to sever the middle tubular element that overlies the longitudinal channel **30015**.

In various embodiments, referring to FIG. **112**, a tissue thickness compensator **44020** can comprise a central tubular element **44080***b* that is at least partially aligned with the longitudinal slot **30015** in the rigid support portion **33010** of the staple cartridge **30000**. The tissue thickness compensator **44020** can further comprise at least one peripheral tubular element **44080***a*, **44080***c* located on a side of the longitudinal slot **30015**. For example, the tissue thickness compensator **44020** can comprise three tubular elements **44080**: a first peripheral tubular element **44080***a* can be longitudinally positioned on a first side of the longitudinal slot **30015** of the staple cartridge **30000**, a central tubular element **44080***b* can be substantially positioned over and/or aligned with the longitudinal slot **30015**, and a second peripheral tubular element **44080***c* can be longitudinally positioned on a second side of the longitudinal slot **30015**. In some embodiments, the central tubular element **44080***b* can comprise a horizontal diameter that is substantially elongated relative to the vertical diameter. In various embodiments, the central tubular element **44080***b*, and/or any other tubular element, can overlap multiples rows of staple cavities **30012**. Referring still to FIG. **112**, the central tubular element **44080***b* can overlap four staple rows of staple cavities **30012** and each peripheral tubular element **44080***a*, **44080***c* can overlap a single row of staple cavities **30012**, for example. In other embodiments, the central tubular element **44080***b* can overlap less than four rows of staple cavities **30012**, such as, for example, two rows of staple cavities **30012**, for example. Further, peripheral tubular elements **44080***a*, **44080***c* can overlap more than one row of staple cavities **30012**, such as, for example, two rows of staple cavities **30012**. Referring now to FIG. **113**, a central tubular element **44180***b* of a tissue thickness compensator **44120** can comprise a therapeutic agent **44198** in a lumen **44184** of the central tubular element **44180***b*. In various embodiments, central tubular element **44180***b* and/or at least one peripheral tubular element **44080***a*, **44080***c* can comprise the therapeutic agent **44198** and/or any other suitable therapeutic agent.

In various embodiments, referring to FIG. **114**, the tissue thickness compensator **44220** can comprise a shell **44224**, which can be similar to overmold material **32024** described herein. In various embodiments, the shell **44224** retains multiple tubular elements **44080** in position in the end effector **12**. The shell **44224** can be coextruded with the tubular elements **44080**. In some embodiments, the tubular elements **44080** can comprise a tubular lattice **44092** of strands **44090**. Similar to the polymeric compositions described in embodiments herein, the shell **44224** can comprise polyglycolic acid (PGA), poly(lactic acid) (PLA), and/or any other suitable bioabsorbable, biocompatible elastomeric polymers, for example. Further, the shell **44224** can be non-porous such that the shell **44224** forms a fluid-impervious layer in the tissue thickness compensator **44220**, for example. Further to the discussion herein, the tubular element **44080** and/or the strands **44090** in the tubular lattice **44092** can comprise a therapeutic agent **44098**. In some embodiments, the non-porous shell **44224** can contain the therapeutic agent **44098** within the tissue thickness compensator. As described herein, the tubular element **44080** can be positioned relative to staple cavities **30012** and a cutting element **30052** in staple cartridge **30000**. In several such embodiments, deployment of the staples **30030** and/or translation of the cutting element **30052** can be configured to pierce or rupture the non-porous, shell **44224** such that the therapeutic agent **44198** contained therein can be released from the tissue thickness compensator **44020**.

Referring to FIG. **115**, a tissue thickness compensator **44320** can comprise a central tubular element **44380***b* comprising a tubular lattice **44392**. The tubular lattice **44392** can have a non-woven portion or a gap **44381** that is substantially aligned with the longitudinal slot **30015** of the rigid support portion **30010**. In such embodiments, a woven portion of the tubular lattice **44092** of the tubular element **44380***b* does not overlap the longitudinal slot **30015**. Accordingly, the cutting element **30052** on the translating staple-fire sled **30052** can translate along the longitudinal slot **30015** without severing an overlapping a woven portion of the tubular lattice **44392**. Though staples **30030***c* and **30030***d* positioned adjacent to the gap **44381** in tubular element **44380***b* may receive less support from the tubular lattice **44392** structure, in some embodiments, additional features can provide support for those staples **30030** and/or additional restoring force in the staple entrapment areas **30039** thereof. For example, as described in greater detail herein, additional tubular elements, support webbing, springs and/or buttressing material can be positioned at least one of inside and outside tubular element **44380***b* near gap **44381**, for example.

Referring now to FIGS. **116-119**, in various embodiments, a tissue thickness compensator **45020** can comprise multiple tubular elements **45080** that laterally traverse the staple cartridge **30000**. The tubular elements **45080** can be positioned perpendicular to the rows of staple cavities **30012** and/or the longitudinal axis of the rigid support portion **30010** of the staple cartridge **30000**. In some embodiments, referring to FIG. **116**, the tubular elements **45080** can traverse the longitudinal slot **30015** in the staple cartridge **30000** such that the cutting element **30052** on the staple-firing sled **30050** is configured to sever the tubular elements **45080** as the staple-firing sled **30050** translates along the longitudinal slot **30015**. In other embodiments, referring now to FIG. **117**, the tissue thickness compensator **46020** can comprise two sets of laterally traversing tubular elements **46080**. The first set of laterally traversing tubular elements **46080***a* can be positioned on a first side of the longitudinal slot **30015** and the second set of laterally traversing tubular elements **46080***b* can be positioned on a second side of the longitudinal slot **30015**. In such an arrangement, the cutting element **30052** can be configured to pass between the two sets of tubular elements **46080** without severing a portion of the tubular elements **46080**. In other embodiments, the cutting element **30052** can sever at least one tubular element **46080** that traverses the longitudinal slot **30015** while at least one other tubular element **46080** does not traverse the longitudinal slot **30015** and is not severed by the cutting element **30052**.

As the tubular elements **45080** laterally traverse the staple cartridge **30000**, referring to FIGS. **118** and **119**, a staple **30030** can engage at least one tubular element **45080** in each staple entrapment area **30039**. In such an arrangement, each tubular element **45080** can provide a discrete restoring force along the length of the staple cartridge **30000**. For example, referring primarily to FIG. **119**, the tubular elements **45080** positioned near the proximal end of the tissue thickness compensator **45020** where the tissue is thicker can be greatly compressed compared to the tubular elements **45080** positioned near to the distal end of the tissue thickness compensator **45020** where the tissue is thinner. As a result, the tubular elements **45080** positioned closer to the proximal end of the tissue thickness compensator **45020** can provide a greater restoring force than the restoring force that could be generated by the tubular elements **46080** positioned closer to the distal end of the tissue thickness compensator **45020**. Further, referring still to FIG. **119**, the deformation of one tube **45080** can have little or no impact on the deformation of an adjacent tube **45080**. Accordingly, the tubular elements **45080** can exert a substantially discrete and customized springback force in staple entrapment areas **30039** along the length of the staple cartridge **30030**. In some embodiments, where multiple staples **30030** fired from a single row of staple cavities **30012** engage the same tubular element **35080**, the deformation of the tubular element **35080** can be less customized. For example, the deformation of a tubular element **35080** in one staple entrapment area **30039** can impact the deformation of that tubular element **35080** in another staple entrapment area **30039**.

In still other embodiments, referring to FIGS. **120-125**, tubular elements **47080** of the tissue thickness compensator **47020** can diagonally traverse the staple cartridge **30000**. The tubular elements **47080** can traverse the longitudinal slot **30015** of the staple cartridge **30000** such that the cutting element **30052** on the staple-firing sled **30050** is configured to sever the diagonally traversing tubular elements **47080** as the staple-firing sled **30052** translates along the longitudinal slot **30015**. In other embodiments, the tissue thickness compensator **47020** can comprise two sets of diagonally traversing tubular elements **47080**. A first set of diagonally traversing tubular elements **47080** can be positioned on a first side of the longitudinal slot **30015** and a second set of diagonally traversing tubular elements **47080** can be positioned on a second side of the longitudinal slot **30015**. In such an arrangement, the cutting element **30052** can pass between the two sets of tubular elements **47080** and may not sever any tubular element **47080**.

Referring still to FIGS. **120-123**, the diagonally traversing tubular elements **47080** can be positioned in the staple cartridge **30000** such that a gap is defined between the tubular elements **47080**. A gap between adjacent tubular elements **47080** can provide space for horizontal expansion of the tubular elements **47080** when a compressive force is applied thereto, such as, for example, by tissue T captured within the staple entrapment area **30039** of the formed staple **30030**. The tubular elements **47080** can be connected across a gap by a film or sheet of material **47024**. The sheet of material can be positioned on at least one of the deck surface **30011** of the rigid support portion **30010** and/or the tissue contacting side of the tubular elements **47080**.

In various embodiments, referring to FIGS. **124** and **125**, at least one diagonally traversing tubular element **47080** can be positioned relative to the staple cavities **30012** in the staple cartridge **30000** such that the tubular element **47080** is positioned between the legs **30032** of the staples **30030** deployed from multiple rows of staple cavities **30012**. As the staples **30030** are moved from the initial position to the fired position, as described in greater detail herein, the staple legs **30032** can remain positioned around the tubular element **47080**. Further, the staples can be deformed such that the staple legs **30032** wrap around the perimeter of the tubular element **47080**, for example. In such an arrangement, the staples **30030** can be configured to move to the fired or formed position without piercing the tubular element **47080**. Movement of the staple legs **30032** around the tubular element **47080** could in some embodiments, prevent the inadvertent release of a therapeutic agent **47098** retained therein. The selected angular orientation of each tubular element **47080** relative to the longitudinal slot **30015** of the staple cartridge **30000** can depend on the position of the staple cavities **30012** in the staple cartridge **30000**. For example, in some embodiments, the tubular elements **47080** can be positioned at an approximately forty-five (45) degree angle relative to the longitudinal slot **30015** of the staple cartridge **30000**. In other embodiments, the tubular elements **47080** can be positioned at a fifteen (15) to seventy-five (75) degree angle relative to the longitudinal slot **30015** of the staple cartridge **30000**, for example.

Similar to descriptions throughout the present disclosure, multiple tubular elements in a tissue thickness compensator can be connected by a binding agent, wrap, webbing, overmold, compensation material, and/or any other suitable connecting adhesive or structure, for example. In various embodiments, referring to FIGS. **126-128**, a flexible shell **48024** may surround or encapsulate tubular elements **48080** in a tissue thickness compensator **48020**. In various embodiments, the flexible shell **48024** can restrain the tubular elements **48080** in the end effector **12** and can hold each tubular element **48080** in position, such as, for example, in longitudinal alignment with a row of staple cavities **30012**. In at least one embodiment, the tissue thickness compensator **48020** can comprise six tubular elements **48080**, for example. In various embodiments, the flexible shell **48024** can be sufficiently deformable and resilient to restrain the tubular elements **48020** encased therein while permitting deformation and rebound of the tubular elements **48080**. Further, in some embodiments, the flexible shell **48024** can tautly surround the tubular elements **48080** and can remain tautly engaged with the tubular elements **48080** as they deform and/or rebound.

Referring to FIG. **127**, prior to the deployment of staples **30030**, the anvil **30060** can be pivoted or rotated downwardly to compress the tissue thickness compensator **48020** and tissue T between the anvil **30060** and the staple cartridge **30000**. Compression of the tissue thickness compensator **48020** can include a corresponding compression of the flexible shell

48024 and the tubular elements 48020 therein. As the tubular elements 48020 deform, the flexible shell 48024 can similarly deform. In various embodiments, the tubular elements 48020 can be uniformly compressed across the width of the staple cartridge 30000 and the flexible shell 48024 can experience a similarly uniform compression across the tubular elements 48080. Referring to FIG. 128, when the anvil 30060 is opened after the staples 30030 have been deployed from the staple cartridge 30000, the tubular elements 48080 can rebound or partially rebound from the compressed configurations (FIG. 127). In various embodiments, a tubular element 48080 can rebound such that the tubular element 48080 returns to its initial, undeformed configuration. In some embodiments, a tubular element 48080 can partially rebound such that the tubular element 48080 partially returns to its initial undeformed configuration. For example, the deformation of the tubular element 48080 can be partially elastic and partially plastic. As the tubular elements 48080 rebound, the flexible shell 48024 can remain tautly engaged with each tubular element 48080. The tubular elements 48080 and flexible shell 48024 can rebound to such a degree that the tubular elements 48080 and tissue T fill the staple entrapment areas 30039 while the tubular elements 48080 exert an appropriate restoring force on the tissue T therein. Referring to FIG. 129, in other embodiments, a tissue thickness compensator 48120 comprising six tubular elements 48180 retained in a flexible shell 48124 can be positioned on the anvil 30060 of the end effector 12, for example.

Referring to FIGS. 130-133, a tissue thickness compensator 49020 can comprise a tubular element 49080 longitudinally positioned along the longitudinal axis of the anvil 30060. In various embodiments, the tissue thickness compensator 49020 can be secured to the anvil 30060 of the end effector 12 by a compressible compensation material 49024. Further, the compressible compensation material 49024 can surround or encapsulate the tubular element 49080. Similar to the descriptions herein, the tubular element 49080 can comprise at least one therapeutic agent 49098 which may be released by the absorption of various components of the tissue thickness compensator 49020, the piercing of the tubular element 49080 by staples 30030 fired from the staple cartridge 30000, and/or by the cutting element 30052.

Referring to FIG. 131, a staple cartridge 30000 can comprise staples 30030 positioned in staple cavities 30012, wherein, prior to deployment of the staples 30030, the anvil 30060 and the tissue thickness compensator 49020 attached thereto can pivot toward the staple cartridge 30000 and compress tissue T captured therebetween. In some embodiments, the tubular element 49080 of the tissue thickness compensator 49020 can be uniformly deformed along the length of the staple cartridge 30000 by the pivoting anvil 30060 (FIG. 131). Referring to FIGS. 132 and 133, the staple-firing sled 30050 can translate along the longitudinal slot 30015 in the staple cartridge 30000 and engage each driver 30040 positioned beneath a staple 30030 in a staple cavity 30010, wherein each engaged driver 30040 can fire or eject the staple 30030 from the staple cavity 30012. When the anvil 30060 releases pressure on the tissue T and the tissue thickness compensator 49020, the tissue thickness compensator 49020, including the tubular element 49080 and the compressible compensation material 49024, can rebound or partially rebound from the compressed configurations (FIG. 131) to a rebounded configuration (FIGS. 132 and 133). The tubular element 49080 and compressible compensation material 49024 can rebound to such a degree that the tissue thickness compensator 49020 and tissue T fill the staple entrapment areas 30039 while the tissue thickness compensator 49020 exert an a restoring force on the captured tissue T.

In various embodiments, referring to FIGS. 124-126, two tissue thickness compensators 50020*a*, 50020*b* can be positioned in the end effector 12 of a surgical instrument. For example, a first tissue thickness compensator 50020*a* can be attached to the staple cartridge 30000 in the lower jaw 30070 and a second tissue thickness compensator 50020*b* can be attached to the anvil 30060. In at least one embodiment, the first tissue thickness compensator 50020*a* can comprise a plurality of tubular elements 50080 longitudinally arranged and retained in a first compensation material 50024*a*. At least one tubular element 50080 can comprise a therapeutic agent 50098, similar to the therapeutic agents described herein. The first compensation material 50024*a* can be deformable or substantially rigid. Further, in some embodiments, the first compensation material 50024*a* can hold the tubular elements 50080 in position relative to the staple channel 30000. For example, the first compensation material 50024*a* can hold each tubular element 50080 in longitudinal alignment with a row of staple cavities 30012. In at least one embodiment, the second tissue thickness compensator 50020*b* can comprise the first compensation material 50024*a*, a second compensation material 50024*b* and/or a third compensation material 50024*c*. The second and third compensation material 50024*b*, 50024*c* can be deformable or substantially rigid.

Similar to at least one embodiment described herein, the anvil 30060 can pivot and apply a compressive force to the tissue thickness compensators 50020*a*, 50020*b* and the tissue T between the anvil 30060 and the staple cartridge 30000. In some embodiments, neither the first tissue thickness compensators 50020*a* nor the second tissue thickness compensators 50020*b* can be compressible. In other embodiments, at least one component of the first tissue thickness compensators 50020*a* and/or the second tissue thickness compensators 50020*b* can be compressible. When the staples 30030 are fired from the staple cartridge 30000, referring now to FIGS. 135 and 136, each staple 30030 can pierce a tubular element 50080 retained in the first tissue thickness compensator 50020*a*. As shown in FIG. 135, the therapeutic agent 50098 retained in the tubular element 50080 can be released when a staple 30030 pierces the tubular element 50080. When released, the therapeutic agent 50098 can coat the staple legs 30032 and tissue T surrounding the fired staple 30030. In various embodiments, the staples 30030 can also pierce the second tissue thickness compensator 50020*b* when the staples 30030 are fired from the staple cartridge 30000.

Referring to FIGS. 137-140, a tissue thickness compensator 51020 can comprise at least one tubular element 51080 that laterally traverses the tissue thickness compensator 51020. For example, referring to FIG. 137, the tissue thickness compensator 51020 can be positioned relative to the staple cartridge 30000 such that a first end 51083 of the laterally traversing tubular element 51080 can be positioned near a first longitudinal side of the staple cartridge 30000 and a second end 51085 of the laterally traversing tubular element 51080 can be positioned near a second longitudinal side of the staple cartridge 30000. In various embodiments, the tubular element 51080 can comprise a capsule-like shape, for example. As illustrated in FIG. 138, the tubular element 51080 can be perforated between the first end 51083 and the second end 51085 and, in some embodiments, the tubular element 51080 can be perforated at or near the center 51087 of the tubular element 51080. The tubular element 51080 can comprise a polymeric composition, such as a bioabsorbable, biocompatible elastomeric polymer, for example. Further, referring again to FIG. **137**, the tissue thickness compensator **51020** can comprise a plurality of laterally traversing tubular elements **51080**. In at least one embodiment, thirteen tubular elements **51080** can be laterally arranged in the tissue thickness compensator **51020**, for example.

Referring again to FIG. **137**, the tissue thickness compensator **51020** can further comprise a compensation material **51024** that at least partially surrounds the tubular elements **51080**. In various embodiments, the compensation material **51024** can comprise a bioabsorbable polymer, such as, for example, lyophilized polysaccharide, glycoprotein, elastin, proteoglycan, gelatin, collagen, and/or oxidized regenerated cellulose (ORC). The compensation material **51024** can hold the tubular elements **51080** in position in the tissue thickness compensator **51020**. Further, the compensation material **51024** can be secured to the top deck surface **30011** of the rigid support portion **30010** of the staple cartridge **30000** such that the compensation material **51020** is securely positioned in the end effector **12**. In some embodiments, the compensation material **51024** can comprise at least one medicament **51098**.

Still referring to FIG. **137**, laterally positioned tubular elements **51080** can be positioned relative to the translating cutting element **30052** such that the cutting element **30052** is configured to sever the tubular elements **51080**. In various embodiments, the cutting element **30052** can sever the tubular elements **51080** at or near the perforation therein. When the tubular elements **51080** are severed in two halves, the severed portions of the tubular elements **51080** can be configured to swell or expand, as illustrated in FIG. **139**. For example, in various embodiments, the tubular element **51080** can comprise a hydrophilic substance **51099** that can be released and/or exposed when the tubular element **51080** is severed. Furthermore, when the hydrophilic substance **51099** contacts bodily fluids in tissue T, the hydrophilic substance **51099** can attract the fluid, which can cause the tubular element **51080** to swell or expand. As the tubular element **51080** expands, the compensation material **51024** surrounding the tubular element **51080** can shift or adjust to accommodate the swollen tubular element **51080**. For example, when the compensation material **51024** comprises gelatin, the gelatin can shift to accommodate the swollen tubular elements **51080**. Referring now to FIG. **140**, expansion of the tubular elements **51080** and shifting of the compensation material **51024** can cause a corresponding expansion of the tissue thickness compensator **51020**.

Similar to other tissue thickness compensators discussed throughout the present disclosure, the tissue thickness compensator **51020** can be deformed or compressed by an applied force. Further, the tissue thickness compensator **51020** can be sufficiently resilient such that it produces a springback force when deformed by the applied force and can subsequently rebound or partially rebound when the applied force is removed. In various embodiments, when the tissue thickness compensator **51020** is captured in a staple entrapment area **30039**, the staple **30030** can deform the tissue thickness compensator **51020**. For example, the staple **30030** can deform the tubular elements **51080** and/or the compensation material **51024** of the tissue thickness compensator **51020** that are captured within the fired staple **30030**. In various embodiments, non-captured portions of the tissue thickness compensator **51020** can also be deformed due to the deformation in the staple entrapment areas **30039**. When deformed, the tissue thickness compensator **51020** can seek to rebound from the deformed configuration. In various embodiments, such a rebound may occur prior to the hydrophilic expansion of the tubular element **51080**, simultaneously with the hydrophilic expansion of the tubular element **51080**, and/or after the hydrophilic expansion of the tubular element **51080**. As the tissue thickness compensator **51020** seeks to rebound, it can exert a restoring force on the tissue also captured in the staple entrapment area **30039**, as described in greater detail herein.

In various embodiments, at least one of the tubular elements **51080** and/or the compensation material **51024** in the tissue thickness compensator **51020** can comprise a therapeutic agent **51098**. When the tubular element **51080** that contains a therapeutic agent **51098** is severed, the therapeutic agent **51098** contained within the tubular elements **51080** can be released. Furthermore, when the compensation material **51024** comprises the therapeutic agent **51098**, the therapeutic agent **51098** can be released as the bioabsorbable compensation material **51024** is absorbed. In various embodiments, the tissue thickness compensator **51020** can provide for a rapid initial release of the therapeutic agent **51098** followed by a controlled release of the therapeutic agent **51098**. For example, the tissue thickness compensator **51020** can provide a rapid initial release of the therapeutic agent **51098** from the tubular elements **51080** to the tissue T along the cut line when the tubular elements **51080** comprising the therapeutic agent **51098** are severed. Further, as the bioabsorbable compensation material **51024** comprising the therapeutic agent **51098** is absorbed, the tissue thickness compensator **51020** can provide an extended, controlled release of the therapeutic agent **51098**. In some embodiments, at least some of the therapeutic agent **51098** can remain in the tubular element **51080** for a short period of time before the therapeutic agent **51098** flows into the compensation material **51024**. In other embodiments, at least some of the therapeutic agent **51098** can remain in the tubular element **51080** until the tubular element **51080** is absorbed. In various embodiments, the therapeutic agent **51098** released from the tubular element **51080** and the compensation material **51024** can be the same. In other embodiments, the tubular element **51080** and the compensation material **51024** can comprise different therapeutic agents or different combinations of therapeutic agents, for example.

Referring still to FIG. **140**, in various embodiments, the end effector **12** can cut tissue T and fire staples **30030** into the severed tissue T nearly simultaneously or in quick succession. In such embodiments, a staple **30030** can be deployed into the tissue T immediately after the cutting element **30052** has severed the tubular element **51080** adjacent to the tissue T. In other words, the staples **30030** can engage the tissue thickness compensator **51020** immediately following or simultaneously with the swelling of the tubular element **51080** and the expansion of the tissue thickness compensator **51020**. In various embodiments, the tissue thickness compensator **51020** can continue to grow or expand after the staples **30030** have been fired into the tissue T. In various embodiments, the staples **30030** can be configured to puncture the tubular elements **51080** when the staples **30030** are deployed. In such embodiments, therapeutic agents **51098** still retained in the severed tubular elements **51080** can be released from the tubular elements **51080** and, in some embodiments, can cover the legs **30031** of the fired staples **30030**.

Referring to FIG. **141**, the tissue thickness compensator **51020** can be manufactured by a molding technique, for example. In various embodiments, a frame, or a mold, **51120** can comprise a first longitudinal side **51122** and a second longitudinal side **51124**. Each longitudinal side **51124** can comprise one or more notches **51130**, which can each be configured to receive the first or second end **50183**, **50185** of a tubular element **51080**. In some embodiments, the first end **50183** of the tubular element **51080** can be positioned in a first notch **51130***a* on the first longitudinal side **51122** and the second end **50183** of the tubular element **51080** can be positioned in a second notch **51130***b* on the second longitudinal side **51124** such that the tubular element **51080** laterally traverses the frame **51120**. In various embodiments, the notch **51180** can comprise a semi-circular groove, which can securely fit the first or second end **50183**, **50185** of the tubular element **51080** therein. In various embodiments, the first notch **51130***a* can be positioned directly across from the second notch **51130***b* and the tubular element **51080** can be positioned perpendicular, or at least substantially perpendicular, to the longitudinal axis of the frame **51120**. In other embodiments, the first notch **51130***a* can be offset from the second notch **51130***b* such that the tubular element **51080** is angularly positioned relative to the longitudinal axis of the frame **51120**. In still other embodiments, at least one tubular element **51080** can be longitudinally positioned within the frame **51120** such that the tubular element extends between the lateral sides **51126**, **51128** of the frame **51120**. Further, at least one tubular element can be angularly positioned in the frame between two notches on the lateral sides **51126**, **51128** of the frame and/or between a notch on a lateral side **51126** and a notch on a longitudinal side **51124**, for example. In various embodiments, the frame **51120** can comprise a support ledge **51136**, which can support the tubular elements **51080** positioned within the frame **51120**.

In various embodiments, the frame **51120** can comprise notches **51130** to accommodate twelve tubular elements **51080**, for example. In some embodiments, the frame notches **51130** can be filled with tubular elements **51080** while, in other embodiments, less than all of the notches **51130** may be filled. In various embodiments, at least one tubular element **51080** can be positioned in the frame **51120**. In some embodiments, at least half the notches **51130** can receive tubular elements **51080**. In at least one embodiment, once the tubular elements **51080** are positioned in the frame **51120**, compensation material **51024** can be added to the frame **51120**. The compensation material **51024** can be fluidic when added to the frame **51120**. For example, in various embodiments, the compensation material **51024** can be poured into the frame **51120** and can flow around the tubular elements **51080** positioned therein. Referring to FIG. **142**, the fluidic compensation material **51024** can flow around the tubular element **51080** supported by notches **51130** in the frame **51120**. After the compensation material **51024** cures, or at least sufficiently cures, referring now to FIG. **143**, the tissue thickness compensator **51020** comprising the compensation material **51024** and tubular elements **51080** can be removed from the frame **51120**. In at least one embodiment, the tissue thickness compensator **51020** can be trimmed. For example, excess compensation material **51024** can be removed from the tissue thickness compensator **51020** such that the longitudinal sides of the compensation material are substantially planar. Furthermore, in some embodiments, referring to FIG. **144**, the first and second ends **50183**, **50185** of the tubular elements **51080** can be pressed together, or closed, to seal the tubular element **51080**. In some embodiments, the ends can be closed before the tubular elements **51080** are placed in the frame **51120**. In other embodiments, the trimming process may transect the ends **51083**, **51085** and a heat stacking process can be used to seal and/or close the ends **51083**, **51085** of the tubular elements **51080**.

In various embodiments, referring again to FIG. **141**, a stiffening pin **51127** can be positioned within each tubular element **51080**. For example, the stiffening pin **51127** can extend through a longitudinal lumen of the tubular element **51080**. In some embodiments, the stiffening pin **51127** can extend beyond each tubular element **51080** such that the stiffening pin **51127** can be positioned in notches **51130** in the frame **51120**. In embodiments having stiffening pins **51127**, the stiffening pins **51127** can support the tubular elements **51080** when the compensation material **51204** is poured into the frame **51120** and as the fluidic compensation material **51024** flows around the tubular elements **51080**, for example. Once the compensation material **51024** cures, solidifies, and/or lyophilizes or sufficiently cures, solidifies, and/or lyophilizes the tissue thickness compensator **51020** can be removed from the frame **51120** and the stiffening pins **51127** can be removed from the longitudinal lumens of the tubular elements **51080**. In some embodiments, the tubular elements **51080** can then be filled with medicaments, for example. Similar to at least one embodiment described herein, after the tubular elements **51080** are filled with medicaments, the tissue thickness compensator **51020**, including the ends **51083**, **51085** of the tubular elements **51080**, for example, can be trimmed. In various embodiments, the tissue thickness compensator **51020** can be die cut, for example, and/or sealed by heat and/or pressure, for example.

As discussed herein, the tissue thickness compensator **52020** can comprise multiple tubular elements **51080**. Referring now to FIG. **145**, the tubular elements **51080** can comprise different material properties, dimensions and geometries. For example, a first tubular element **51080***a* can comprise a first thickness and a first material and a second tubular element **51080***b* can comprise a second thickness and a second material. In various embodiments, at least two tubular elements **51080** in the tissue thickness compensator **52020** can comprise the same material. In other embodiments, each tubular element **51080** in the tissue thickness compensator **5202** can comprise different materials. Similarly, in various embodiments, at least two tubular elements **51080** in the tissue thickness compensator **52020** can comprise the same geometry. In other embodiments, each tubular element **51080** in the tissue thickness compensator **52020** can comprise different geometries.

Referring now to FIGS. **208**-**211**, a tissue thickness compensator **51220** can comprise at least one tubular element **51280** that laterally traverses the tissue thickness compensator **51220**. In various embodiments, referring to FIG. **208**, the tissue thickness compensator **51220** can be positioned relative to the anvil **30060** of the end effector **12**. The tissue thickness compensator **51220** can be secured to a securing surface **30061** of the anvil **30060** of the end effector **12**, for example. In various embodiments, referring primarily to FIG. **209**, the tubular element **51280** can comprise a capsule-like shape, for example. The tubular element **51280** can comprise a polymeric composition, such as a bioabsorbable, biocompatible elastomeric polymer, for example.

Referring again to FIG. **208**, the tissue thickness compensator **51220** can further comprise a compensation material **51224** that at least partially surrounds the tubular elements **51280**. In various embodiments, the compensation material **51224** can comprise a bioabsorbable polymer, such as, for example, lyophilized polysaccharide, glycoprotein, elastin, proteoglycan, gelatin, collagen, and/or oxidized regenerated cellulose (ORC), for example. Similar to the above, the compensation material **51024** can hold the tubular elements **51280** in position in the tissue thickness compensator **51220**. Further, the compensation material **51224** can be secured to the securing surface **30061** of the anvil **30060** such that the compensation material **51220** is securely positioned in the end effector **12**. In some embodiments, the compensation material **51224** can comprise at least one medicate.

Still referring to FIG. **208**, the laterally positioned tubular elements **51280** can be positioned relative to the cutting element **30252** on a translating sled **30250** such that the translatable cutting element **30252** is configured to sever the tubular elements **51280**. In various embodiments, the cutting element **30252** can sever the tubular elements **51280** at or near the center of each tubular element **51280**, for example. When the tubular elements **51280** are severed in two halves, the severed portions of the tubular elements **51280** can be configured to swell or expand, as illustrated in FIG. **208**. Referring primarily to FIG. **210**, in various embodiments, a tubular element **51280** can comprise a hydrophilic substance **51099** that can be released and/or exposed when the tubular element **51280** is severed. Furthermore, referring now to FIG. **211**, when the hydrophilic substance **51099** contacts bodily fluids in the tissue T, the hydrophilic substance **51099** can attract the fluid, which can cause the tubular element **51280** to swell or expand. As the tubular element **51280** expands, the compensation material **51224** surrounding the tubular element **51280** can shift or adjust to accommodate the swollen tubular element **51280**. For example, when the compensation material **51224** comprises gelatin, the gelatin can shift to accommodate the swollen tubular element **51280**. Referring again to FIG. **208**, expansion of the tubular elements **51280** and shifting of the compensation material **51224** can cause a corresponding expansion of the tissue thickness compensator **51220**.

Similar to other tissue thickness compensators discussed throughout the present disclosure, the tissue thickness compensator **51220** can be deformed or compressed by an applied force. Further, the tissue thickness compensator **51220** can be sufficiently resilient such that it produces a springback force when deformed by the applied force and can subsequently rebound or partially rebound when the applied force is removed. In various embodiments, when the tissue thickness compensator **51220** is captured in a staple entrapment area **30039** (FIG. **88**), the staple **30030** can deform the tissue thickness compensator **51220**. For example, the staple **30030** can deform the tubular elements **51280** and/or the compensation material **51224** of the tissue thickness compensator **51220** captured within the fired staple **30030**. In various embodiments, non-captured portions of the tissue thickness compensator **51220** can also be deformed due to the deformation in the staple entrapment areas **30039**. When deformed, the tissue thickness compensator **51220** can seek to rebound from the deformed configuration. In various embodiments, such a rebound may occur prior to the hydrophilic expansion of the tubular element **51280**, simultaneously with the hydrophilic expansion of the tubular element **51280**, and/or after the hydrophilic expansion of the tubular element **51280**. As the tissue thickness compensator **51220** seeks to rebound, it can exert a restoring force on the tissue also captured in the staple entrapment area **30039**, as described in greater detail herein.

Referring to FIGS. **146-149**, a tissue thickness compensator **52020** can comprise one or more tubular elements **52080** that laterally traverse the tissue thickness compensator **52020**, similar to at least one tissue thickness compensator described herein. In various embodiments, the tissue thickness compensator **52020** can comprise multiple laterally traversing tubular elements **52080**. The tissue thickness compensator **52020** can further comprise one or more sheets of material **52024** that hold or retain at least one tubular element **52080** in the tissue thickness compensator **52020**. In various embodiments, the one or more sheets of material **52024** can be positioned above and/or below the tubular elements **52080** and can securely retain each tubular element **52080** in the tissue thickness compensator **52020**. Referring primarily to FIG. **146**, the tissue thickness compensator can comprise a first sheet of material **52024***a* and a second sheet of material **52024***b*. In various embodiments, the tubular elements **52080** can be positioned between the first and second sheets of material **52024***a*, **52024***b*. Further, referring still to FIG. **146**, the sheet of material **52024***b* can be secured to the top deck surface **30011** of the rigid support portion of the staple cartridge **30000** such that the tissue thickness compensator **52020** is securely positioned in the end effector **12**. In other embodiments, one or more of the sheets of material **52024** can be secured to the anvil **30060** or otherwise retained in the end effector **12**.

In various embodiments, referring primarily to FIG. **147**, the tissue thickness compensator **52020** can be porous and/or permeable. For example, the sheet of material **52024** can comprise a plurality of apertures **52026**. In various embodiments, the apertures **52026** can be substantially circular. In at least one embodiment, the apertures **52036** can be visible in the sheet of material **52024**. In other embodiments, the apertures **52036** can be microscopic. Referring still to FIG. **147**, the tubular elements **52080** can comprise a plurality of apertures **52026**, as well. In various embodiments, referring to FIG. **148**, a tissue thickness compensator **52120** can comprise a sheet of material **52124** that comprises a plurality of non-circular apertures **52126**. For example, the apertures **52126** can comprise a diamond and/or slotted shape. In various other embodiments, referring to FIG. **149**, a tissue thickness compensator **52220** can comprise a tubular element **52280** that comprises a permeable tubular lattice **52292**. In various embodiments, the sheet of material **52224** can comprise a bioabsorbable, biocompatible elastomeric polymer and can comprise a medicament, for example.

Similar to at least one embodiment described herein, at least one tubular element **52080** can be configured to swell or expand, as illustrated in FIGS. **150**A-**150**D. For example, referring to FIG. **150**A, the tubular elements **52080** can be positioned intermediate the first and second sheet of material **52024***a*, **52024***b* in the tissue thickness compensator **52020**. When the tissue thickness compensator **52020** contacts tissue T, as illustrated in FIG. **150**B, the tissue thickness compensator **52020** can expand. In various embodiments, for example, the tubular elements **52080** can comprise a hydrophilic substance **52099** that expands when exposed to fluid in and/or on the tissue T. Further, the sheet of material **52024** and tubular elements **52080** can be permeable, as described herein, such that fluid from the tissue T can permeate the tissue thickness compensator **52020** thereby allowing the fluid to contact the hydrophilic substance **52099** within the tubular elements **52080**. As the tubular elements **52080** expand, the sheet of material **52024** surrounding the tubular elements **52080** can shift or adjust to accommodate the swollen tubular elements **52080**. Similar to various tissue thickness compensators discussed throughout the present disclosure, the expanded tissue thickness compensator **52020** can be deformed or compressed by an applied force, such as, for example, a compressive force applied by fired staples, as illustrated in FIG. **150**C. Further, the tissue thickness compensator **52020** can be sufficiently resilient such that it produces a springback force when deformed by the applied force and can subsequently rebound when the applied force is removed. Referring now to FIGS. **150**D and **150**E, the tissue thickness compensator **52020** can rebound to different configurations in different staple entrapment areas **30039** to appropriately accommodate the captured tissue T.

Referring to FIGS. **151-156**, a tissue thickness compensator **53020** can comprise a plurality of vertically positioned tubular elements **53080**. In various embodiments, each tubular element **53080** can comprise a tubular axis that is substantially perpendicular to the top deck surface **30011** of the rigid support portion **30010** of the staple cartridge **30000**. Further, the first end of each tubular element **53080** can be positioned adjacent to the top deck surface **30011**, for example. Similar to at least one embodiment described herein, the tubular elements **53080** can be deformable and may comprise an elastomeric polymer, for example. In various embodiments, as illustrated in FIG. **152**, the tubular elements **53080** can be compressed when captured in a staple entrapment area **30039** with stapled tissue T. A tubular element **53080** can comprise an elastic material such that deformation of the tubular element **53080** generates a restoring force as the tubular element **53080** seeks to rebound from the deformed configuration. In some embodiments, deformation of the tubular element **53080** can be at least partially elastic and at least partially plastic. The tubular element **53080** can be configured to act as a spring under an applied force and, in various embodiments, can be configured not to buckle. In various embodiments, referring to FIG. **153**, the tubular elements **53080** can be substantially cylindrical. In some embodiments, referring to FIG. **154**, a tubular element **53180** can comprise a buckling region **53112**. The tubular element **53180** can be configured to buckle or deform at the buckling region **53112** when a compressive force is applied thereto. The tubular element **53180** can deform elastically and/or plastically and then be designed to buckle suddenly at the buckling region **53112** under a preselected buckling force.

Referring primarily to FIG. **155**, a first tubular element **53080** can be positioned at a first end of a staple cavity **30012** and another tubular element **53080** can be positioned at a second end of the staple cavity **30012**. As illustrated in FIG. **153**, the tubular element **53080** can comprise a lumen **53084** extending therethrough. Referring again to FIG. **152**, when the staple **30030** is moved from the initial position to the fired position, each staple leg **30032** can be configured to pass through a lumen **53084** of each tubular element **53080**. In various other embodiments, referring primarily to FIG. **156**, vertically positioned tubular elements **54080** can be arranged in a tissue thickness compensator **54020** such that the tubular elements **54080** abut or contact each other. In other words, the tubular elements **54080** can be clustered or gathered together. In some embodiments, the tubular elements **54080** can be systematically arranged in the tissue thickness compensator **54020**; however, in other embodiments, the tubular elements **54080** can be randomly arranged.

Referring again to FIGS. **151**, **155**, and **156**, the tissue thickness compensator **53020** can also comprise a sheet of material **53024** that holds or retains the tubular elements **53080** in the tissue thickness compensator **53020**. In various embodiments, the sheet of material **53024** can be positioned above and/or below the tubular elements **53080** and can securely retain each tubular element **53080** in the tissue thickness compensator **53020**. In various embodiments, the tissue thickness compensator **53020** can comprise a first and a second sheet of material **53024**. In various embodiments, the tubular elements **53080** can be positioned between the first and second sheets of material **53024**. Further, the sheet of material **53024** can be secured to the top deck surface **30011** of the rigid support portion of the staple cartridge **30000** such that the tissue thickness compensator **53020** is securely positioned in the end effector **12**. In other embodiments, a sheet of material **53024** can be secured to the anvil **30060** or otherwise retained in the end effector **12**. Similar to at least one embodiment described herein, the sheet of material **53024** can be sufficiently deformable such that the sheet of material **53024** deforms as springs **55080** within the tissue thickness compensator are deformed.

Referring to FIGS. **157** and **158**, a tissue thickness compensator **55020** can comprise at least one spring **55080** that is sufficiently resilient such that it is capable of producing a springback force when deformed. Referring primarily to FIG. **157**, the tissue thickness compensator **55020** can comprise a plurality of springs **55080**, such as, for example, three rows of springs **55080**. The springs **55080** can be systematically and/or randomly arranged in the tissue thickness compensator **55020**. In various embodiments, the springs **55080** can comprise an elastomeric polymer, for example. In some embodiments, the shape of the springs **55080** can allow for deformation thereof. In various embodiments, the springs **55080** can be deformed from an initial configuration to a deformed configuration. For example, when a portion of the tissue thickness compensator **55020** is captured in a staple entrapment area **30039**, the springs **55080** in and/or around the staple entrapment area **30039** can be deformed. In various embodiments, the springs **55080** can buckle or collapse under a compressive force applied for a fired staple **30030** and the springs **55080** may generate a restoring force that is a function of the spring rate of the deformed spring **55080** and/or the amount the spring **55080** is deformed, for example. In some embodiments, the spring **55080** can act as a sponge under a compressive force applied by a fired staple **30030**. Further, the spring **55080** can comprise a compensation material, as described in greater detail throughout the present disclosure.

The tissue thickness compensator **55020** can further comprise one or more sheets of material **55024** that hold or retain at least one spring **55080** in the tissue thickness compensator **55020**. In various embodiments, the sheets of material **55024** can be positioned above and/or below the springs **55080** and can securely retain the springs **55080** in the tissue thickness compensator **55020**. In at least one embodiment, the tissue thickness compensator **55020** can comprise a first sheet of material **55024*a*** and a second sheet of material **55024*b***. In various embodiments, the tubular elements **52080** can be positioned between the first and second sheets of material **55024*a***, **55024*b***. Referring primarily to FIG. **158**, in various embodiments, the tissue thickness compensator **55020** can further comprise a third sheet of material **55024*c*** positioned adjacent to either the first or second sheet of material **55024*a***, **55024*b***. In various embodiments, at least one sheet of material **55024** can be secured to the top deck surface **30011** of the rigid support portion of the staple cartridge **30000**, such that the tissue thickness compensator **55020** is securely positioned in the end effector **12**. In other embodiments, at least one sheet of material **55024** can be secured to the anvil **30060** or otherwise retained in the end effector **12**.

Referring now to FIG. **158**, when a staple **30030** is fired from the staple cartridge **30000** (FIG. **156**), the staple **30030** can engage the tissue thickness compensator **55020**. In various embodiments, the fired staple **30030** can capture tissue T and a portion of the tissue thickness compensator **55020** in the staple entrapment area **30039**. The springs **55080** can be deformable such that the tissue thickness compensator **55020** compresses when captured by a fired staple **30030**. In some embodiments, the springs **55080** can be positioned between fired staples **30030** in the tissue thickness compensator **55020**. In other embodiments, at least one spring **55080** can be captured within the staple entrapment area **30039**.

Referring to FIG. **159**, a tissue thickness compensator **60020** can comprise at least two compensation layers **60022**. In various embodiments, the tissue thickness compensator **60020** can comprise a plurality of compensation layers **60022** which can be stacked on top of each other, positioned side-by-side, or a combination thereof. As described in greater detail herein, the compensation layers **60022** of the tissue thickness compensator **60020** can comprise different geometric and/or material properties, for example. Furthermore, as described in greater detail herein, pockets and/or channels can exist between adjacently stacked compensation layers **60022**. For example, a tissue thickness compensator **62020** can comprise six compensation layers **62022***a*, **62022***b*, **62022***c*, **62022***d*, **62022***e*, **62022***f*, which can be adjacently stacked on top of each other (FIG. **174**).

Referring to FIGS. **160**, **161**, and **163-168**, a tissue thickness compensator can comprise a first compensation layer **60122***a* and a second compensation layer **60122***b*. In various embodiments, the first compensation layer **60122***a* can be adjacently stacked on top of the second compensation layer **60122***b*. In at least one embodiment, adjacently stacked compensation layers **60122** can be separated by a separation gap or pocket **60132**. Referring primarily to FIG. **160**, a tissue thickness compensator **60120** can also comprise at least one cantilever beam or support **60124** positioned between the first and second compensation layers **60122***a*, **60122***b*. In various embodiments, the support **60124** can be configured to position the first compensation layer **60122***a* relative to the second compensation layer **60122***b* such that compensation layers **60122** are separated by the separation gap **60132**. As described in greater detail herein, deformation of the support **60124** and/or the compensation layers **60122***a*, **60122***b*, for example, can reduce the separation gap **60132**.

The support beam of a tissue thickness compensator can comprise various geometries and dimensions. For example, the support beam can be a simple I-beam, a centered, single-bend support beam **60124** (FIG. **160**), an off-centered, single-bend support beam **60224** (FIG. **161**), an elliptical support beam **60324** (FIG. **163**), a multi-bend support beam **60424** (FIG. **164**), and/or a symmetrical, dual-cantilevered support beam **60524** (FIG. **165**). Furthermore, referring now to FIGS. **160**, **166**, and **167**, a support beam **60624** can be thinner than at least one compensation layer **60122** (FIG. **166**), a support beam **60724** can be thicker than at least one compensation layer **60122** (FIG. **167**), and/or a support beam **60124** can be substantially the same thickness as at least one compensation layer **60122** (FIG. **160**), for example. The material, geometry and/or dimensions of the support beam **60124**, for example, can affect the deformability and springback resiliency of the tissue thickness compensator **60120**.

Referring still to FIG. **160**, the compensation layers **60122** and support beam **60124** of the tissue thickness compensator **60120** can comprise different materials, such as, for example, structural material, biological material, and/or electrical material, for example. For example, in various embodiments, at least one compensation layer **60122** can comprise a polymeric composition. The polymeric composition can comprise an at least partially elastic material such that deformation of the compensation layer **60122** and/or the support beam **60124** can generate a springback force. The polymeric composition of the compensation layer **60122** can comprise non-absorbable polymers, absorbable polymers, or combinations thereof. In some embodiments, the absorbable polymers can include bioabsorbable, biocompatible elastomeric polymers, for example. Furthermore, the polymeric composition of the compensation layer **60122** can comprise synthetic polymers, non-synthetic polymers, or combinations thereof. Examples of synthetic polymers include, but are not limited to, polyglycolic acid (PGA), poly(lactic acid) (PLA), polycaprolactone (PCL), polydioxanone (PDO), and copolymers thereof. Examples of non-synthetic polymers include, but are not limited to, polysaccharides, glycoprotein, elastin, proteoglycan, gelatin, collagen, and oxidized regenerated cellulose (ORC). In various embodiments, similar to the polymeric compositions in embodiments described herein, the polymeric composition of the compensation layers **60122** can include varied amounts of absorbable polymers, non-absorbable polymers, synthetic polymers, and non-synthetic polymers, for example, by weight percentage. In various embodiments, each compensation layer **60022** in the tissue thickness compensator **60120** can comprise a different polymeric composition or, in various other embodiments, at least two compensation layers **60122** can comprise the same polymeric composition.

Referring again to FIG. **159**, in various embodiments, at least one compensation layer **60022** can comprise a therapeutic agent **60098** such as a medicament or pharmaceutically active agent, for example. The compensation layer **60022** can release a therapeutically effective amount of the therapeutic agent **60098**. In various embodiments, the therapeutic agent **60098** can be released as the compensation layer **60022** is absorbed. Examples of therapeutic agents **60098** can include, but are not limited to, haemostatic agents and drugs, such as, for example, fibrin, thrombin, and/or oxidized regenerated cellulose (ORC), anti-inflammatory drugs such as, for example, diclofenac, aspirin, naproxen, sulindac, and/or hydrocortisone antibiotic and antimicrobial drugs or agents such as, for example, triclosan, ionic silver, ampicillin, gentamicin, polymyxin B, and/or chloramphenicol, and/or anticancer agents such as, for example, cisplatin, mitomycin, and/or adriamycin. In some embodiments, the therapeutic agent **60098** can comprise a biologic, such as a stem cell, for example. In various embodiments, each compensation layer **60022** in a tissue thickness compensator **60020** can comprise a different therapeutic agent **60098** or, in various other embodiments, at least two compensation layers **60022** can comprise the same therapeutic agent **60098**. In at least one embodiment, a compensation layer **60022** comprising a therapeutic agent **60098**, such as a biologic, for example, can be encased between two structural compensation layers **60022** comprising a polymeric composition, such as, for example, polyglycolic acid (PGA) foam, for example. In various embodiments, a compensation layer **60022** can also comprise an electrically conductive material, such as, for example, copper.

In various embodiments, referring again to FIG. **174**, the compensation layers **62022** in the tissue thickness compensator **62020** can have different geometries. When layers **62022** are adjacently positioned in the tissue thickness compensator **62020**, the compensation layers **62022** can form at least one three-dimensional conduit **62032** between the layers **62022**. For example, when a second compensation layer **62022***b* comprising a channel is positioned above a substantially flat third compensation layer **62022***c*, the channel and flat surface of the third compensation layer **62022***c* can define a three-dimensional conduit **62032***a* therebetween. Similarly, for example, when a fifth compensation layer **62022***e* comprising a channel is positioned below a fourth compensation layer **62022***d* comprising a corresponding channel, the channels can form a three-dimensional conduit **62032***b* defined by the channels in the adjacently stacked compensation layers **62022***d*, **62022***e*. In various embodiments, the conduits **62032** can direct therapeutic agents and/or bodily fluids as the fluids flow through the tissue thickness compensator **62020**.

In various embodiments, referring to FIG. **170**, a tissue thickness compensator **61020** can comprise compensation layers **61022**, such as layers **60122***a* and **21022***b*, configured to receive staples **30030** deployed from the staple cartridge **20000** (FIG. **169**). As a staple **30030** is moved from an initial position to a fired position, the geometry of at least one compensation layer **61022** can guide the staple legs **30032** to the fired position. In various embodiments, at least one compensation layer **61022** can comprise apertures **61030** extending therethrough, wherein the apertures **61030** can be arranged to receive the staple legs **30032** of deployed staples **30030** when the staples **30030** are fired from the staple cartridge **20000** (FIG. **169**), as described in greater detail herein. In various other embodiments, referring again to FIG. **174**, staple legs **30032** can pierce through at least one compensation layer, such as compensation layer **62022***f*, for example, and can be received through apertures **62030** in at least one compensation layer, such as, for example, compensation layer **62022***a*.

Referring primarily to FIG. **170**, the tissue thickness compensator **60120** can comprise at least one support tab **61026** on one of the compensation layers **61022***a*, **61022***b*. The support tab **61026** can protrude into the separation gap **61032** defined between adjacent compensation layers, such as the gap **61032** between the first compensation layer **61020***a* and second compensation layer **61020***b*. In various embodiments, the support tab **61026** can protrude from a longitudinal side of a first compensation layer **61022***a*. Further, the support tab **61026** can extend along the length of the longitudinal side or only along a portion thereof. In various embodiments, at least one support tab **61026** can protrude from two longitudinal sides of the compensation layer **61022***a*, **61022***b*. Further, adjacently positioned compensation layers **61022***a*, **61022***b* can comprise corresponding support tabs **60126**, such that the support tab **60126** that extends from the first compensation layer **60122***a* can at least partially align with the support tab **60126** that extends from the second compensation layer **60122***b*. In at least one embodiment, referring again to FIG. **168**, a tissue thickness compensator **60820** can comprise a limiter plate **60828** between adjacent compensation layers **60122***a*, **60122***b*. The limiter plate **60828** can be positioned in the gap **60132** defined between the first compensation layer **60122***a* and the second compensation layer **60122***b*, for example. As described in greater detail herein, support tab(s) **61026** and/or limiter plate(s) **60828** can control the deformation and/or deflection of a support **60124** and/or the compensation layers **60122***a*, **60122***b*.

As described herein, in various embodiments, the compensation layers **60022** of the tissue thickness compensator **60020** can comprise different materials, geometries and/or dimensions. Such tissue thickness compensators **60020** can be assembled by a variety of manufacturing techniques. Referring primarily to FIG. **159**, the tissue thickness compensator **60022** can be manufactured by lithographic, stereolithographic (SLA), or silk screening processes. For example, a stereolithographic manufacturing process can create a tissue thickness compensator **60020** in which each compensation layer **60022** comprises different materials and/or geometric features. For example, an ultraviolet light in a stereolithography machine can draw the geometry of a first compensation layer **60022**, such that the first compensation layer **60022** comprising a first material, geometry and/or dimensions is cured by the ultraviolet light. The ultraviolet light can subsequently draw the geometry of a second compensation layer **60022**, such that the second compensation layer **60022** comprising a second material, geometry and/or dimensions is cured by the ultraviolet light. In various embodiments, a stereolithography machine can draw compensation layers **60022** on top of each other, side-by-side, or a combination thereof. Further, the compensation layers **60022** can be drawn such that pockets **60132** exist between adjacent compensation layers **60022**. Because a stereolithography machine can create very thin layers having unique geometries, a tissue thickness compensator **60020** manufactured by a stereolithographic process can comprise a very complex three-dimensional geometry.

In various embodiments, referring to FIG. **169**, the tissue thickness compensator **60920** can be positioned in the end effector **12** of a surgical instrument **10** (FIG. **1**). The tissue thickness compensator **60920** can be positioned relative to the staple cartridge **20000** of the end effector **12**. For example, the tissue thickness compensator **60920** can be releasably secured to the staple cartridge **20000**. In at least one embodiment, at least one compensation layer **60922** of the tissue thickness compensator **60920** can be positioned adjacent to the top deck surface **20011** (FIG. **79**) of the staple cartridge **20000**. For example, a second compensation layer **60922***b* can be secured to the top deck surface **20011** by an adhesive or by a wrap, similar to at least one of the wraps described herein (FIG. **16**). In various embodiments, the tissue thickness compensator **60920** can be integral to the staple cartridge **20000** such that the staple cartridge **20000** and the tissue thickness compensator **60920** are formed as a single unit construction. For example, the staple cartridge **20000** can comprise a first body portion, such as the rigid support portion **20010** (FIG. **79**), and a second body portion, such the as tissue thickness compensator **60920**.

Still referring to FIG. **169**, the tissue thickness compensator **60920** can comprise a first compensator portion **60920***a* and a second compensator portion **60920***b*. The first compensator portion **60920***a* can be positioned on a first longitudinal side of the staple cartridge **20000** and the second compensator portion **60920***b* can be positioned on a second longitudinal side of the staple cartridge **20000**. In various embodiments, when the tissue thickness compensator **60920** is positioned relative to the staple cartridge **20000**, the longitudinal slot **20015** (FIG. **78**) in the rigid support portion **20010** (FIG. **78**) can extend between the first compensator portion **60920***a* and the second compensator portion **60920***b*. When the cutting element **20052** on the staple-firing sled **20050** (FIG. **78**) translates through the end effector **12**, the cutting element **20052** can pass through the longitudinal slot **20015** between the first compensator portion **60920***a* and the second compensator portion **60920***b* without severing a portion of the tissue thickness compensator **60920**, for example. In other embodiments, the cutting element **20052** can be configured to sever a portion of the tissue thickness compensator **60920**.

In various embodiments, referring now to FIG. **162**, a tissue thickness compensator **63020** can be configured to fit in the end effector **12'** of a circular surgical instrument. In various embodiments, the tissue thickness compensator **62030** can comprise a circular first compensation layer **63022***a* and a circular second compensation layer **63022***b*. The second compensation layer **63022***b* can be positioned on a circular top deck surface **20011'** of a circular staple cartridge **20000'**, wherein the second compensation layer **63022***b* can comprise a geometry that corresponds to the geometry of the deck surface **20011'**. For example, the deck surface **20011'** can comprise a stepped portion and the second compensation layer **63022***b* can comprise a corresponding stepped portion. Similar to various embodiments described herein, the tissue thickness compensator can further comprise at least one support **63024** and/or support tabs **63026**, for example, extending around the tissue thickness compensator **63020**.

Referring again to FIG. **170**, fired staples **30030** can be configured to engage the tissue thickness compensator **60920**. As described throughout the present disclosure, a fired staple **30030** can capture a portion of the tissue thickness compensator **60920** and tissue T and apply a compressive force to the tissue thickness compensator **60920**. Further, referring primarily to FIGS. **171-173**, the tissue thickness compensator **60920** can be deformable. In various embodiments, as described herein, a first compensation layer **60920***a* can be separated from a second compensation layer **60920***b* by a separation gap **60932**. Referring to FIG. **171**, prior to compression of the tissue thickness compensator **60920**, the gap **60932** can comprise a first distance. When a compressive force A is applied to the tissue thickness compensator **60920** and tissue T, for example, by a fired staple **30030** (FIG. **170**), the support **60924** can be configured to deform. Referring now to FIG. **172**, the single-bend support beam **60924** can bend under the compressive force A such that the separation gap **60932** between the first compensation layer **60920***a* and the second compensation layer **60920***b* is reduced to a second distance. Referring primarily to FIG. **173**, the first and second compensation layers **60922***a*, **60922***b* can also deform under the compressive force A. In various embodiments, the support tabs **60926** can control deformation of the compensation layers **60920**. For example, the support tabs **60926** can prevent excessive bending of the compensation layers **60920** by supporting the longitudinal sides of the compensation layer **60920** when they come into contact with one another. The support tabs **60926** can also be configured to bend or bow under the compressive force A. Additionally or alternatively, the limiter plate **60128** (FIG. **168**) described in greater detail herein, can limit the deformation of the compensation layers **60920** when the compensation layers **60920** and/or support tabs **60926** contact the limiter plate **60128**.

Furthermore, similar to various tissue thickness compensators described herein, tissue thickness compensator **60920** can generate a springback or restoring force when deformed. The restoring force generated by the deformed tissue thickness compensator can at least depend on the orientation, dimensions, material, and/or geometry of the tissue thickness compensator **60920**, as well as the amount of the tissue thickness compensator **60920** that is deformed by the applied force. Furthermore, in various embodiments, at least a portion of the tissue thickness compensator **60920** can be resilient such that the tissue thickness compensator **60920** generates a spring load or restoring force when deformed by a fired staple **30030**. In at least one embodiment, the support **60924** can comprise an elastic material and/or at least one compensation layer **60922** can comprise an elastic material such that the tissue thickness compensator **60920** is resilient.

In various embodiments, referring now to FIG. **175**, an end effector of a surgical stapling instrument can comprise a first jaw and a second jaw, wherein at least one of the first jaw and the second jaw can be configured to be moved relative to the other. In certain embodiments, the end effector can comprise a first jaw including a staple cartridge channel **19070** and a second jaw including an anvil **19060**, wherein the anvil **19060** can be pivoted toward and/or away from the staple cartridge channel **19070**, for example. The staple cartridge channel **19070** can be configured to receive a staple cartridge **19000**, for example, which, in at least one embodiment, can be removably retained within the staple cartridge channel **19070**. In various embodiments, the staple cartridge **19000** can comprise a cartridge body **19010** and a tissue thickness compensator **19020** wherein, in at least one embodiment, the tissue thickness compensator **19020** can be removably attached to the cartridge body **19010**. Similar to other embodiments described herein, referring now to FIG. **176**, the cartridge body **19010** can comprise a plurality of staple cavities **19012** and a staple **19030** positioned within each staple cavity **19012**. Also similar to other embodiments described herein, the staples **19030** can be supported by staple drivers **19040** positioned within the cartridge body **19010** wherein a sled and/or firing member, for example, can be advanced through the staple cartridge **19000** to lift the staple drivers **19040** upwardly within the staple cavities **19012**, as illustrated in FIG. **177**, and eject the staples **19030** from the staple cavities **19012**.

In various embodiments, referring primarily to FIGS. **175** and **176**, the tissue thickness compensator **19020** can comprise resilient members **19022** and a vessel **19024** encapsulating the resilient members **19022**. In at least one embodiment, the vessel **19024** can be sealed and can define a cavity containing an inner atmosphere having a pressure which is different than the surrounding atmospheric pressure. In certain embodiments, the pressure of the inner atmosphere can be greater than the pressure of the surrounding atmosphere while, in other embodiments, the pressure of the inner atmosphere can be less than the pressure of the surrounding atmosphere. In the embodiments in which the vessel **19024** contains a pressure less than the pressure of the surrounding atmosphere, the sidewall of the vessel **19024** can enclose a vacuum. In such embodiments, the vacuum can cause the vessel **19024** to distort, collapse, and/or flatten wherein the resilient members **19022** positioned within the vessel **19024** can be resiliently compressed within the vessel **19024**. When a vacuum is drawn on the vessel **19024**, the resilient members **19022** can deflect or deform downwardly and can be held in position by the sidewalls of the vessel **19024** in a compressed, or vacuum-packed, state.

Resilient member **19022** and vessel **19024** are comprised of biocompatible materials. In various embodiments, resilient member **19022** and/or vessel **19024** can be comprised of bioabsorbable materials such as PLLA, PGA, and/or PCL, for example. In certain embodiments, resilient member **19022** can be comprised of a resilient material. Resilient member **19022** can also comprise structural resilience. For example, resilient member **19022** can be in the form of a hollow tube.

Further to the above, the tissue thickness compensator **19020** can be positioned against or adjacent to the deck surface **19011** of the cartridge body **19010**. When the staples **19030** are at least partially fired, referring now to FIG. **177**, the legs of the staples **19030** can puncture or rupture the vessel **19024**. In certain embodiments, the vessel **19024** can comprise a central portion **19026** which can be positioned over a cutting slot **19016** of the cartridge body **19010** such that, when a cutting member **19080** is advanced to incise tissue T positioned between the staple cartridge **19000** and the anvil **19060**, the cutting member **19080** can also incise the central portion **19026** of the vessel **19024** thereby puncturing or rupturing the vessel **19024**. In either event, once the vessel **19024** has been ruptured, the inner atmosphere within the vessel **19024** can equalize with the atmosphere surrounding the tissue thickness compensator **19020** and allow the resilient members **19022** to resiliently expand to regain, or at least partially regain, their undistorted and/or unflattened configuration. In such circumstances, the resilient members **19022** can apply a biasing force to the tissue T captured within the deformed staples **19020**. More specifically, after being deformed by the forming surfaces of pockets **19062** defined in the anvil **19060**, the legs of the staples **19030** can capture tissue T and at least a portion of a resilient member **19022** within the staples **19030** such that, when the vessel **19024** ruptures, the tissue thickness compensator **19020** can compensate for the thickness of the tissue T captured within the staples **19030**. For instance, when the tissue T captured within a staple **19030** is thinner, a resilient member **19022** captured within that staple **19030** can expand to fill gaps within the staple **19030** and apply a sufficient compression force to the tissue T. Correspondingly, when the tissue T captured within a staple **19030** is thicker, a resilient member **19022** captured within that staple **19030** can remain compressed to make room for the thicker tissue within the staple **19030** and, likewise, apply a sufficient compression force to the tissue T.

When the vessel **19024** is punctured, as outlined above, the resilient members **19022** can expand in an attempt to resiliently return to their original configuration. In certain circumstances, the portion of resilient members **19022** that have been captured within the staples **19030** may not be able to return to their original undistorted shape. In such circumstances, the resilient members **19022** can comprise a spring which can apply a compression force to the tissue T captured within the staples **19030**. In various embodiments, a resilient member **19022** can emulate a linear spring wherein the compression force applied by the resilient member **19022** is linearly proportional to the amount, or distance, in which the resilient member **19022** remains deflected within the staple **19030**. In certain other embodiments, a resilient member **19022** can emulate a non-linear spring wherein the compression force applied by the resilient member **19022** is not linearly proportional to the amount, or distance, in which the resilient member **19022** remains deflected within the staple **19030**.

In various embodiments, referring primarily to FIGS. **178** and **179**, a staple cartridge **19200** can comprise a tissue thickness compensator **19220** which can comprise one or more sealed vessels **19222** therein. In at least one embodiment, each of the vessels **19222** can be sealed and can contain an inner atmosphere. In certain embodiments, the pressure of the inner atmosphere within a sealed vessel **19222** can exceed atmospheric pressure while, in certain other embodiments, the pressure of the inner atmosphere within a sealed vessel **19222** can be below atmospheric pressure. In embodiments where the pressure of the inner atmosphere within a vessel **19222** is below atmospheric pressure, the vessel **19222** can be described as containing a vacuum. In various embodiments, one or more of the vessels **19222** can be wrapped or contained in an outer shroud, container, wrap, and/or film **19224**, for example, wherein the tissue thickness compensator **19220** can be positioned above a deck surface **19011** of the cartridge body **19010**. In certain embodiments, each vessel **19222** can be manufactured from a tube having a circular, or an at least substantially circular, cross-section, for example, having a closed end and an open end. A vacuum can be drawn on the open end of the tube and, when a sufficient vacuum has been reached within the tube, the open end can be closed and sealed. In at least one such embodiment, the tube can be comprised of a polymeric material, for example, wherein the open end of the tube can be heat staked in order to close and seal the same. In any event, the vacuum within each vessel **19222** can pull the sidewalls of the tube inwardly and resiliently distort and/or flatten the tube. The vessels **19222** are illustrated in an at least partially flattened state in FIG. **179**.

When the staples **19030** are in their unfired position, as illustrated in FIG. **179**, the tips of the staples **19030** can be positioned below the tissue thickness compensator **19220**. In at least one such embodiment, the staples **19030** can be positioned within their respective staple cavities **19012** such that the staples **19030** do not contact the vessels **19222** until the staples **19030** are moved from the unfired positions, illustrated in FIG. **179**, to their fired positions, illustrated in FIG. **180**. In certain embodiments, the wrap **19224** of the tissue thickness compensator **19220** can protect the vessels **19220** from being prematurely punctured by the staples **19030**. When the staples **19030** are at least partially fired, referring now to FIG. **180**, the legs of the staples **19030** can puncture or rupture the vessels **19222**. In such circumstances, the inner atmospheres within the vessels **19222** can equalize with the atmosphere surrounding the vessels **19222** and resiliently expand to regain, or at least partially regain, their undistorted and/or unflattened configuration. In such circumstances, the punctured vessels **19222** can apply a biasing force to the tissue captured within the deformed staples **19030**. More specifically, after being deformed by the forming surfaces of pockets **19062** defined in the anvil **19060**, the legs of the staples **19030** can capture tissue T and at least a portion of a vessel **19222** within the staples **19030** such that, when the vessels **19222** rupture, the vessels **19222** can compensate for the thickness of the tissue T captured within the staples **19030**. For instance, when the tissue T captured within a staple **19030** is thinner, a vessel **19222** captured within that staple **19030** can expand to fill gaps within the staple **19030** and, concurrently, apply a sufficient compression force to the tissue T. Correspondingly, when the tissue T captured within a staple **19030** is thicker, a vessel **19222** captured within that staple **19030** can remain compressed to make room for the thicker tissue within the staple **19030** and, concurrently, apply a sufficient compression force to the tissue T.

When the vessels **19222** are punctured, as outlined above, the vessels **19222** can expand in an attempt to resiliently return to their original configuration. The portion of vessels **19222** that have captured within the staples **19030** may not be able to return to their original undistorted shape. In such circumstances, the vessel **19222** can comprise a spring which can apply a compression force to the tissue T captured within the staples **19030**. In various embodiments, a vessel **19222** can emulate a linear spring wherein the compression force applied by the vessel **19222** is linearly proportional to the amount, or distance, in which the vessel **19222** remains deflected within the staple **19030**. In certain other embodiments, a vessel **19222** can emulate a non-linear spring wherein the compression force applied by the vessel **19222** is not linearly proportional to the amount, or distance, in which the vessel **19222** remains deflected within the staple **19030**. In various embodiments, the vessels **19222** can be hollow and, in at least one embodiment, empty when they are in their sealed configuration. In certain other embodiments, each of the vessels **19222** can define a cavity and can further include at least one medicament contained therein. In at least some embodiments, the vessels **19222** can be comprised of at least one medicament which can be released and/or bioabsorbed, for example.

In various embodiments, the vessels **19222** of the tissue thickness compensator **19220** can be arranged in any suitable manner. As illustrated in FIG. **178**, the staple cavities **19012** defined in the cartridge body **19010**, and the staples **19030** positioned in the staple cavities **19012**, can be arranged in rows. In at least the illustrated embodiment, the staple cavities **19012** can be arranged in six longitudinal, linear rows, for example; however, any suitable arrangement of staple cavities **19012** could be utilized. As also illustrated in FIG. **178**, the tissue thickness compensator **19220** can comprise six vessels **19222** wherein each of the vessels **19222** can be aligned with, or positioned over, a row of staple cavities **19012**. In at least one embodiment, each of the staples **19030** within a row of staple cavities **19012** can be configured to puncture the same vessel **19222**. In certain situations, some of the staple legs of the staples **19030** may not puncture the vessel **19222** positioned thereover; however, in embodiments where the vessel **19222** defines a continuous internal cavity, for example, the cavity can be sufficiently punctured by at least one of the staples **19030** in order to allow the pressure of the internal cavity atmosphere to equalize with the atmospheric pressure surrounding the vessel **19222**. In various embodiments, referring now to FIG. **185**, a tissue thickness compensator can comprise a vessel, such as vessel **19222'**, for example, which can extend in a direction which is transverse to a line of staples **19030**. In at least one such embodiment, a vessel **19222'** can extend across multiple staple rows. In certain embodiments, referring now to FIG. **186**, a tissue thickness compensator **19220"** can comprise a plurality of vessels **19222"** which extend in a direction which is perpendicular, or at least substantially perpendicular, to a line of staples **19030**. In at least one such embodiment, some of the vessels **19222"** may be punctured by the staples **19030** while others may not be punctured by the staples **19030**. In at least one embodiment, the vessels **19222"** can extend across or through a cutting path in which a cutting member could transect and rupture the vessels **19222"**, for example.

In various embodiments, as described above, a tissue thickness compensator, such as tissue thickness compensator **19220**, for example, can comprise a plurality of sealed vessels, such as vessels **19222**, for example. As also described above, each of the sealed vessels **19222** can comprise a separate internal atmosphere. In certain embodiments, the vessels **19222** can have different internal pressures. In at least one embodiment, for example, a first vessel **19222** can comprise an internal vacuum having a first pressure and a second vessel **19222** can comprise an internal vacuum having a second, different pressure, for example. In at least one such embodiment, the amount of distortion or flattening of a vessel **19222** can be a function of the vacuum pressure of the internal atmosphere contained therein. For instance, a vessel **19222** having a greater vacuum can be distorted or flattened a greater amount as compared to a vessel **19222** having a smaller vacuum. In certain embodiments, the cavity of a vessel can be segmented into two or more separate, sealed cavities wherein each separate, sealed cavity can comprise a separate internal atmosphere. In at least one such embodiment, some of the staples within a staple row can be configured and arranged to puncture a first cavity defined in the vessel while other staples within the staple row can be configured and arranged to puncture a second cavity defined in the vessel, for example. In such embodiments, especially in embodiments in which the staples in a staple row are sequentially fired from one end of the staple row to the other, as described above, one of the cavities can remain intact and can maintain its internal atmosphere when another cavity is ruptured. In certain embodiments, the first cavity can have an inner atmosphere having a first vacuum pressure and the second cavity can have an inner atmosphere having a second, different vacuum pressure, for example. In various embodiments, a cavity that remains intact can maintain its inner pressure until the vessel is bioabsorbed thereby creating a timed pressure release.

In various embodiments, referring now to FIGS. **181** and **182**, a tissue thickness compensator, such as tissue thickness compensator **19120**, for example, can be attached to an anvil **19160**. Similar to the above, the tissue thickness compensator **19120** can comprise a vessel **19124** and a plurality of resilient members **19122** positioned therein. Also similar to the above, the vessel **19124** can define a cavity containing an inner atmosphere having a pressure which is less than or greater than the pressure of the atmosphere surrounding the tissue thickness compensator **19120**. In embodiments where the inner atmosphere within the vessel **19124** comprises a vacuum, the vessel **19124** and the resilient members **19122** positioned therein can be distorted, collapsed, and/or flattened by the difference in pressure between the vacuum in the vessel **19124** and the atmospheric pressure outside of the vessel **19124**. In use, the anvil **19160** can be moved into a closed position in which it is positioned opposite a staple cartridge **19100** and in which a tissue engaging surface **19121** on the vessel **19124** can engage the tissue T positioned intermediate the tissue thickness compensator **19120** and a staple cartridge **19100**. In use, the firing member **19080** can be advanced distally to fire the staples **19030**, as described above, and, at the same time, incise the tissue T. In at least one embodiment, the tissue thickness compensator **19120** can further comprise an intermediate portion **19126** which can be aligned with a cutting slot defined in the anvil **19160** wherein, when the firing member **19080** is advanced distally through the tissue thickness compensator **19120**, the firing member **19080** can puncture or rupture the vessel **19124**. Also, similar to the above, the firing member **19080** can lift the staple drivers **19040** upwardly and fire the staples **19030** such that the staples **19030** can contact the anvil **19160** and be deformed into their deformed configuration, as illustrated in FIG. **183**. When the staples **19030** are fired, the staples **19030** can pierce the tissue T and then pierce or rupture the vessel **19124** such that the resilient members **19122** positioned within the vessel **19124** can at least partially expand, as outlined above.

In various embodiments, further to the above, a tissue thickness compensator can be comprised of a biocompatible material. The biocompatible material, such as, a foam, may comprise tackifiers, surfactants, fillers, cross-linkers, pigments, dyes, antioxidants and other stabilizers and/or combinations thereof to provide desired properties to the material. In certain embodiments, a biocompatible foam may comprise a surfactant. The surfactant may be applied to the surface of the material and/or dispersed within the material. Without wishing to be bound to any particular theory, the surfactant applied to the biocompatible material may reduce the surface tension of the fluids contacting the material. For example, the surfactant may reduce the surface tension of water contacting the material to accelerate the penetration of water into the material. In various embodiments, the water may act as a catalyst. The surfactant may increase the hydrophilicity of the material.

In various embodiments, the surfactant may comprise an anionic surfactant, a cationic surfactant, and/or a non-ionic surfactant. Examples surfactants include, but are not limited to polyacrylic acid, methalose, methyl cellulose, ethyl cellulose, propyl cellulose, hydroxy ethyl cellulose, carboxy methyl cellulose, polyoxyethylene cetyl ether, polyoxyethylene lauryl ether, polyoxyethylene octyl ether, polyoxyethylene octylphenyl ether, polyoxyethylene oleyl ether, polyoxyethylene sorbitan monolaurate, polyoxyethylene stearyl ether, polyoxyethylene nonylphenyl ether, dialkylphenoxy poly(ethyleneoxy)ethanol, and polyoxamers, and combinations thereof. In at least one embodiment, the surfactant may comprise a copolymer of polyethylene glycol and polypropylene glycol. In at least one embodiment, the surfactant may comprise a phospholipid surfactant. The phospholipid surfactant may provide antibacterial stabilizing properties and/or disperse other materials in the biocompatible material. In various embodiments, the tissue thickness compensator may comprise at least one medicament. The tissue thickness compensator may comprise one or more of the natural materials, non-synthetic materials, and/or synthetic materials described herein. In certain embodiments, the tissue thickness compensator may comprise a biocompatible foam comprising gelatin, collagen, hyaluronic acid, oxidized regenerated cellulose, polyglycolic acid, polycaprolactone, polylactic acid, polydioxanone, polyhydroxyalkanoate, poliglecaprone, and combinations thereof. In certain embodiments, the tissue thickness compensator may comprise a film comprising the at least one medicament. In certain embodiments, the tissue thickness compensator may comprise a biodegradable film comprising the at least one medicament. In certain embodiments, the medicament may comprise a liquid, gel, and/or powder. In various embodiments, the medicaments may comprise anti-cancer agents, such as, for example, cisplatin, mitomycin, and/or adriamycin.

In various embodiments, the tissue thickness compensator may comprise a biodegradable material to provide controlled elution of the at least one medicament as the biodegradable material degrades. In various embodiments, the biodegradable material may degrade may decompose, or loses structural integrity, when the biodegradable material contacts an activator, such as, for example an activator fluid. In various embodiments, the activator fluid may comprise saline or any other electrolyte solution, for example. The biodegradable material may contact the activator fluid by conventional techniques, including, but not limited to spraying, dipping, and/or brushing. In use, for example, a surgeon may dip an end effector and/or a staple cartridge comprising the tissue thickness compensator comprising the at least one medicament into an activator fluid comprising a salt solution, such as sodium chloride, calcium chloride, and/or potassium chloride. The tissue thickness compensator may release the medicament as the tissue thickness compensator degrades. In certain embodiments, the elution of the medicament from the tissue thickness compensator may be characterized by a rapid initial elution rate and a slower sustained elution rate.

In various embodiments, a tissue thickness compensator, for example, can be comprised of a biocompatible material which may comprise an oxidizing agent. In various embodiments, the oxidizing agent may an organic peroxide and/or an inorganic peroxide. Examples of oxidizing agents may include, but are not limited to, hydrogen peroxide, urea peroxide, calcium peroxide, and magnesium peroxide, and sodium percarbonate. In various embodiments, the oxidizing agent may comprise peroxygen-based oxidizing agents and hypohalite-based oxidizing agents, such as, for example, hydrogen peroxide, hypochlorous acid, hypochlorites, hypocrites, and percarbonates. In various embodiments, the oxidizing agent may comprise alkali metal chlorites, hypochlorites and perborates, such as, for example, sodium chlorite, sodium hypochlorite and sodium perborate. In certain embodiments, the oxidizing agent may comprise vanadate. In certain embodiments, the oxidizing agent may comprise ascorbic acid. In certain embodiments, the oxidizing agent may comprise an active oxygen generator. In various embodiments, a tissue scaffold may comprise the biocompatible material comprising an oxidizing agent.

In various embodiments, the biocompatible material may comprise a liquid, gel, and/or powder. In certain embodiments, the oxidizing agent may comprise microparticles and/or nanoparticles, for example. For example, the oxidizing agent may be milled into microparticles and/or nanoparticles. In certain embodiments, the oxidizing agent may be incorporated into the biocompatible material by suspending the oxidizing agent in a polymer solution. In certain embodiments, the oxidizing agent may be incorporated into the biocompatible material during the lyophilization process. After lyophilization, the oxidizing agent may be attached to the cell walls of the biocompatible material to interact with the tissue upon contact. In various embodiments, the oxidizing agent may not be chemically bonded to the biocompatible material. In at least one embodiment, a percarbonate dry power may be embedded within a biocompatible foam to provide a prolonged biological effect by the slow release of oxygen. In at least one embodiment, a percarbonate dry power may be embedded within a polymeric fiber in a non-woven structure to provide a prolonged biological effect by the slow release of oxygen. In various embodiments, the biocompatible material may comprise an oxidizing agent and a medicament, such as, for example, doxycycline and ascorbic acid.

In various embodiments, the biocompatible material may comprise a rapid release oxidizing agent and/or a slower sustained release oxidizing agent. In certain embodiments, the elution of the oxidizing agent from the biocompatible material may be characterized by a rapid initial elution rate and a slower sustained elution rate. In various embodiments, the oxidizing agent may generate oxygen when the oxidizing agent contacts bodily fluid, such as, for example, water. Examples of bodily fluids may include, but are not limited to, blood, plasma, peritoneal fluid, cerebral spinal fluid, urine, lymph fluid, synovial fluid, vitreous fluid, saliva, gastrointestinal luminal contents, and/or bile. Without wishing to be bound to any particular theory, the oxidizing agent may reduce cell death, enhance tissue viability and/or maintain the mechanical strength of the tissue to tissue that may be damaged during cutting and/or stapling. In various embodiments, the biocompatible material may comprise at least one microparticle and/or nanoparticle. The biocompatible material may comprise one or more of the natural materials, non-synthetic materials, and synthetic materials described herein. In various embodiments, the biocompatible material may comprise particles having a mean diameter of about 10 nm to about 100 nm and/or about 10 μm to about 100 μm, such as, for example, 45-50 nm and/or 45-50 μm. In various embodiments, the biocompatible material may comprise biocompatible foam comprising at least one microparticle and/or nanoparticle embedded therein. The microparticle and/or nanoparticle may not be chemically bonded to the biocompatible material. The microparticle and/or nanoparticle may provide controlled release of the medicament. In certain embodiments, the microparticle and/or nanoparticle may comprise at least one medicament. In certain embodiments, the microparticle and/or nanoparticle may comprise a hemostatic agent, an anti-microbial agent, and/or an oxidizing agent, for example. In certain embodiments, the tissue thickness compensator may comprise a biocompatible foam comprising an hemostatic agent comprising oxidized regenerated cellulose, an anti-microbial agent comprising doxycline and/or Gentamicin, and/or an oxidizing agent comprising a percarbant. In various embodiments, the microparticle and/or nanoparticle may provide controlled release of the medicament up to three days, for example.

In various embodiments, the microparticle and/or nanoparticle may be embedded in the biocompatible material during a manufacturing process. For example, a biocompatible polymer, such as, for example, a PGA/PCL, may contact a solvent, such as, for example, dioxane to form a mixture. The biocompatible polymer may be ground to form particles. Dry particles, with or without ORC particles, may be contacted with the mixture to form a suspension. The suspension may be lyophilized to form a biocompatible foam comprising PGA/PCL having dry particles and/or ORC particles embedded therein.

In various embodiments, the tissue thickness compensators or layers disclosed herein can be comprised of an absorbable polymer, for example. In certain embodiments, a tissue thickness compensator can be comprised of foam, film, fibrous woven, fibrous non-woven PGA, PGA/PCL (Poly (glycolic acid-co-caprolactone)), PLA/PCL (Poly(lactic acid-co-polycaprolactone)), PLLA/PCL, PGA/TMC (Poly (glycolic acid-co-trimethylene carbonate)), PDS, PEPBO or other absorbable polyurethane, polyester, polycarbonate, Polyorthoesters, Polyanhydrides, Polyesteramides, and/or

Polyoxaesters, for example. In various embodiments, a tissue thickness compensator can be comprised of PGA/PLA (Poly (glycolic acid-co-lactic acid)) and/or PDS/PLA (Poly(p-dioxanone-co-lactic acid)), for example. In various embodiments, a tissue thickness compensator can be comprised of an organic material, for example. In certain embodiments, a tissue thickness compensator can be comprised of Carboxymethyl Cellulose, Sodium Alginate, Cross-linked Hyaluronic Acid, and/or Oxidized regenerated cellulose, for example. In various embodiments, a tissue thickness compensator can comprise a durometer in the 3-7 Shore A (30-50 Shore OO) ranges with a maximum stiffness of 15 Shore A (65 Shore OO), for example. In certain embodiments, a tissue thickness compensator can undergo 40% compression under 3 lbf load, 60% compression under 6 lbf load, and/or 80% compression under 20 lbf load, for example. In certain embodiments, one or more gasses, such as air, nitrogen, carbon dioxide, and/or oxygen, for example, can be bubbled through and/or contained within the tissue thickness compensator. In at least one embodiment, a tissue thickness compensator can comprise beads therein which comprise between approximately 50% and approximately 75% of the material stiffness comprising the tissue thickness compensator.

In various embodiments, a tissue thickness compensator can comprise hyaluronic acid, nutrients, fibrin, thrombin, platelet rich plasma, Sulfasalazine (Azulfidine®–5ASA+ Sulfapyridine diazo bond))–prodrug–colonic bacterial (Azoreductase), Mesalamine (5ASA with different prodrug configurations for delayed release), Asacol® (5ASA+ Eudragit-S coated–pH>7 (coating dissolution)), Pentasa® (5ASA+ethylcellulose coated–time/pH dependent slow release), Mesasal® (5ASA+Eudragit-L coated–pH>6), Olsalazine (5ASA+5ASA–colonic bacterial (Azoreductase)), Balsalazide (5ASA+4-Aminobenzoyl-B-alanine)–colonic bacterial (Azoreductase)), Granulated mesalamine, Lialda (delay and SR formulation of mesalamine), HMPL-004 (herbal mixture that may inhibit TNF-alpha, interleukin-1 beta, and nuclear-kappa B activation), CCX282-B (oral chemokine receptor antagonist that interferes with trafficking of T lymphocytes into the intestinal mucosa), Rifaximin (nonabsorbable broad-spectrum antibiotic), Infliximab, murine chymieric (monoclonal antibody directed against TNF-alpha-approved for reducing signs/symptoms and maintaining clinical remission in adult/pediatric patients with moderate/severe luminal and fistulizing Crohn's disease who have had inadequate response to conventional therapy), Adalimumab, Total Human IgG1 (anti-TNF-alpha monoclonal antibody-approved for reducing signs/symptoms of Crohn's disease, and for the induction and maintenance of clinical remission in adult patients with moderate/severe active Crohn's disease with inadequate response to conventional therapies, or who become intolerant to Infliximab), Certolizumab pegoll, humanized anti-TNF FAB' (monoclonal antibody fragment linked to polyethylene glycol-approved for reducing signs/symptoms of Crohn's disease and for the induction and maintenance of response in adult patients w/moderate/severe disease with inadequate response to conventional therapies), Natalizumab, First non-TNF-alpha inhibitor (biologic compound approved for Crohn's disease), Humanized monoclonal IgG4 antibody (directed against alpha-4 integrin-FDA approved for inducing and maintaining clinical response and remission in patients with moderate/severe disease with evidence of inflammation and who have had inadequate response to or are unable to tolerate conventional Crohn's therapies and inhibitors of TNF-alpha), concomitant Immunomodulators potentially given with Infliximab, Azathioprine 6-Mercaptopurine (purine synthesis inhibitor-prodrug), Methotrexate (binds dihydrofolate reductase (DHFR) enzyme that participates in tetrahydrofolate synthesis, inhibits all purine synthesis), Allopurinol and Thioprine therapy, PPI, H2 for acid suppression to protect the healing line, C-Diff-Flagyl, Vancomycin (fecal translocation treatment; probiotics; repopulation of normal endoluminal flora), and/or Rifaximin (treatment of bacterial overgrowth (notably hepatic encephalopathy); not absorbed in GI tract with action on intraluminal bacteria), for example.

As described herein, a tissue thickness compensator can compensate for variations in the thickness of tissue that is captured within the staples ejected from a staple cartridge and/or contained within a staple line, for example. Stated another way, certain staples within a staple line can capture thick portions of the tissue while other staples within the staple line can capture thin portions of the tissue. In such circumstances, the tissue thickness compensator can assume different heights or thicknesses within the staples and apply a compressive force to the tissue captured within the staples regardless of whether the captured tissue is thick or thin. In various embodiments, a tissue thickness compensator can compensate for variations in the hardness of the tissue. For instance, certain staples within a staple line can capture highly compressible portions of the tissue while other staples within the staple line can capture portions of the tissue which are less compressible. In such circumstances, the tissue thickness compensator can be configured to assume a smaller height within the staples that have captured tissue having a lower compressibility, or higher hardness, and, correspondingly, a larger height within the staples that have captured tissue having a higher compressibility, or lower hardness, for example. In any event, a tissue thickness compensator, regardless of whether it compensates for variations in tissue thickness and/or variations in tissue hardness, for example, can be referred to as a 'tissue compensator' and/or as a 'compensator', for example.

The devices disclosed herein can be designed to be disposed of after a single use, or they can be designed to be used multiple times. In either case, however, the device can be reconditioned for reuse after at least one use. Reconditioning can include any combination of the steps of disassembly of the device, followed by cleaning or replacement of particular pieces, and subsequent reassembly. In particular, the device can be disassembled, and any number of the particular pieces or parts of the device can be selectively replaced or removed in any combination. Upon cleaning and/or replacement of particular parts, the device can be reassembled for subsequent use either at a reconditioning facility, or by a surgical team immediately prior to a surgical procedure. Those skilled in the art will appreciate that reconditioning of a device can utilize a variety of techniques for disassembly, cleaning/replacement, and reassembly. Use of such techniques, and the resulting reconditioned device, are all within the scope of the present application.

Preferably, the invention described herein will be processed before surgery. First, a new or used instrument is obtained and if necessary cleaned. The instrument can then be sterilized. In one sterilization technique, the instrument is placed in a closed and sealed container, such as a plastic or TYVEK bag. The container and instrument are then placed in a field of radiation that can penetrate the container, such as gamma radiation, x-rays, or high-energy electrons. The radiation kills bacteria on the instrument and in the container. The sterilized instrument can then be stored in the sterile container. The sealed container keeps the instrument sterile until it is opened in the medical facility.

Any patent, publication, or other disclosure material, in whole or in part, that is said to be incorporated by reference herein is incorporated herein only to the extent that the incorporated materials does not conflict with existing definitions, statements, or other disclosure material set forth in this disclosure. As such, and to the extent necessary, the disclosure as explicitly set forth herein supersedes any conflicting material incorporated herein by reference. Any material, or portion thereof, that is said to be incorporated by reference herein, but which conflicts with existing definitions, statements, or other disclosure material set forth herein will only be incorporated to the extent that no conflict arises between that incorporated material and the existing disclosure material.

While this invention has been described as having exemplary designs, the present invention may be further modified within the spirit and scope of the disclosure. This application is therefore intended to cover any variations, uses, or adaptations of the invention using its general principles. Further, this application is intended to cover such departures from the present disclosure as come within known or customary practice in the art to which this invention pertains.

What is claimed is:

1. A fastener cartridge assembly for a surgical instrument, the fastener cartridge assembly comprising:

- a cartridge body comprising a longitudinal row of fastener cavities;
- a deformable tube positioned relative to said cartridge body, wherein said deformable tube comprises a resilient material, and wherein said deformable tube comprises:
  - a top portion;
  - a bottom portion;
  - a first end;
  - a second end; and
  - a tubular channel intermediate said top portion and said bottom portion and extending between said first end and said second end, wherein said top portion and said bottom portion are positioned above said cartridge body; and
- a fastener moveable between an initial position and a fired position, wherein said fastener is positioned in a fastener cavity in said row of fastener cavities when said fastener is in said initial position, and wherein said fastener is configured to engage a portion of said deformable tube when said fastener is moved to said fired position.

2. The fastener cartridge assembly of claim **1**, wherein said cartridge body further comprises a deck, wherein said deformable tube overlies at least a portion of said longitudinal row of fastener cavities.

3. The fastener cartridge assembly of claim **2**, wherein said deformable tube is positioned adjacent to said deck of said cartridge body.

4. The fastener cartridge assembly of claim **2**, wherein said cartridge body comprises a plurality of substantially parallel rows of fastener cavities, wherein said plurality of substantially parallel rows of fastener cavities comprises said longitudinal row of fastner cavities, and wherein said cartridge body further comprises:

- a slot extending between two said substantially parallel rows of fastener cavities; and
- a cutting element configured to translate within said slot, wherein at least a portion of said deformable tube overlies said slot such that said cutting element is configured to cut at least a portion of said deformable tube.

5. The fastener cartridge assembly of claim **2**, wherein said deformable tube comprises a first deformable tube, wherein the fastener cartridge assembly further comprises a second deformable tube, wherein said second deformable tube is substantially parallel to said first deformable tube.

6. The fastener cartridge assembly of claim **5**, wherein said second deformable tube is positioned within said first deformable tube.

7. The fastener cartridge assembly of claim **6**, further comprising a third deformable tube, wherein said third deformable tube is positioned within said second deformable tube.

8. The fastener cartridge assembly of claim **5**, further comprising a third deformable tube, wherein said first deformable tube is aligned with a longitudinal axis defined by said cartridge body, wherein said second deformable tube is positioned on a first side of said first deformable tube, and wherein said third deformable tube is positioned on a second side of said first deformable tube.

9. The fastener cartridge assembly of claim **5**, wherein said first deformable tube and said second deformable tube are coextruded with an adjoining portion to form a single piece.

10. The fastener cartridge assembly of claim **1**, wherein said deformable tube comprises a lattice of strands woven together to form a tube wall.

11. The fastener cartridge assembly of claim **10**, wherein said lattice of strands comprises tubular strands.

12. The fastener cartridge assembly of claim **10**, wherein said lattice of strands comprises bioabsorbable strands.

13. The fastener cartridge assembly of claim **10**, wherein said deformable tube further comprises a non-porous tube positioned one of outside and inside said lattice of strands, and wherein said non-porous tube is coextruded with said lattice of strands.

14. The fastener cartridge assembly of claim **13**, wherein said lattice of strands is at least partially filled with a therapeutic agent to treat tissue.

15. A fastener cartridge for a surgical instrument, the fastener cartridge comprising:

- a cartridge body defining a longitudinal axis;
- a first plurality of strands woven into a resilient lattice, wherein said resilient lattice is substantially parallel to said longitudinal axis, and wherein said resilient lattice comprises:
  - a top wall;
  - a bottom wall; and
  - a channel intermediate said top wall and said bottom wall, wherein said top wall and said bottom wall are positioned above said cartridge body; and
- fasteners moveable between an initial position and a fired position, wherein at least one said fastener is configured to compress a portion of said resilient lattice when said at least one fastener is moved to said fired position.

16. The fastener cartridge of claim **15**, wherein said resilient lattice comprises a first resilient lattice, wherein said fastener cartridge further comprises a second plurality of strands woven into a second resilient lattice, wherein said second resilient lattice is substantially parallel to said longitudinal axis, and wherein at least one of said first plurality of strands and said second plurality of strands comprises tubular strands.

17. An end effector assembly for a surgical instrument, the end effector assembly comprising:

- an anvil;
- a fastener cartridge, comprising:
  - at least one row of fastener cavities; and
  - fasteners moveable between an initial position and a fired position, wherein each said fastener is positioned in a said fastener cavity when each said fastener is in said initial position; and

a tube, wherein said tube comprises a resilient material, wherein said tube is substantially parallel to said at least one row of fastener cavities, and wherein said tube comprises:

a top portion;

a bottom portion; and

a tubular passage intermediate said top portion and said bottom portion, wherein said top portion and said bottom portion are positioned between said anvil and said fastener cartridge;

wherein at least one said fastener, when moved to said fired position, is configured to deform a portion of said tube.

18. The end effector assembly of claim **17**, wherein said tube comprises a therapeutic agent to treat tissue.

19. The end effector assembly of claim **18**, wherein said tube is bioabsorbable such that said tube releases said therapeutic agent as said tube is being bioabsorbed.

20. The end effector assembly of claim **18**, further comprising a cutting element configured to translate along at least a portion of a slot in said fastener cartridge, wherein at least one of said cutting element and said fasteners is configured to penetrate said tube such that said therapeutic agent is released from said tube.

* * * * *